Many barnacles.

Many worm-tubes, both limy and built of sand.

One small holothurian.

Two hydroid colonies with many small crustaceans (*Caprella*) among the branches.

Several small crabs and a number of other small crustaceans.

Several colonies of encrusting bryozoans.

Two small sponges.

One annelid worm.

One flat worm.

Egg-cases of *Cantharus tincta, Muricidea multangula* and *Anachis avara similis.*

Twenty-five different kinds of animal life, more than a hundred individuals of eight different phyla were living on an area approximating 55 or 60 square inches of the shell surface of one *Atrina.* Only creatures seen by the unaided eye are noted. The microscope would have revealed many more.

LOUISE M. PERRY

SANIBEL, FLORIDA

A GONAD PARASITE OF THE STARFISH

CÉPÈDE in 1910[1] described the astomate holotrichidan, *Orchitophyra stellarum,* from the testis of *Asterias rubens.* He remarked that this protozoan is confined to male starfish, where it causes castration. Piatt in 1935[2] has found this parasite in the testis of *Asterias forbesi* in Long Island Sound.

During the summers of 1934 and 1935 this protozoan was found in the ovaries of *Asterias vulgaris,* which were taken from the oyster beds in Malpeque Bay, Prince Edward Island. This is apparently the first record of this parasite infesting starfish ovaries. There was no obvious pathological condition of any

CORNELIUS ROSSE

EARLY SCIENCE IN OXFORD

VI

A PROSPECT OF THE HOSPITALL CALLED BEDLAM

R. White, sculpsit

Built by Robert Hooke in 1676

EARLY SCIENCE IN OXFORD

BY

R. T. GUNTHER

VOL. VI

THE LIFE AND WORK OF ROBERT HOOKE

(PART I)

OXFORD
PRINTED FOR THE AUTHOR
1930

PRINTED IN GREAT BRITAIN
AT THE OXFORD UNIVERSITY PRESS
BY JOHN JOHNSON

TO

THE PRESIDENT AND FELLOWS

OF

THE ROYAL COLLEGE OF PHYSICIANS

WHO IN THEIR NEW HOUSE IN PALL MALL

HAVE PRESERVED

A PART OF ONE OF THE ARCHITECTURAL

WORKS OF HOOKE

VIZ. THE DECORATIVE PANELLING

FROM THEIR ANCIENT HOME

IN WARWICK LANE

THIS BOOK

IS

DEDICATED

PREFACE

ROBERT HOOKE was one of the most brilliant of that illustrious band of Oxford men of science who took part in the really great Oxford Movement, which resulted in the foundation of the Royal Society, and in establishing its prestige. All his work is characterized by pre-eminent sanity and utility. His many discoveries and inventions were of the greatest interest to his contemporaries both in Oxford and in London, and have now become so essential a part of modern civilization that we, whose lives are regulated by those inventions, are in danger of forgetting the inventor. Somehow it comes easier to us to honour a man who has achieved the North Pole, than one whose memorial we all carry on our wrists, or in our watch-pockets. The vital Spring that Hooke added to the balance-wheel of time-keepers, and the Anchor-escapement of pendulum clocks are but two of his thousand inventions.

The Wheel-barometer, which we hopefully tap in the halls of country hotels, was also of his contriving. And at a time when there was the greatest diversity of opinion as to the proper way of marking temperatures, he suggested that the Freezing-point on a Thermometer Scale should be represented by Zero or 0°.

'I adjust the Thermometer,' he wrote, 'putting all the degrees of heat and cold above and below the freezing mark, where I begin my account, or 0, and marking them with +1, +2, +3 etc. above that mark; and with −1, −2, −3, etc. below the same.'

Had he been a countryman of Galileo or Goethe, the whole world would now be ringing with his fame. As it is, it is doubtful if any one in his native town has ever heard of him. Yet, in Oxford, in association with the less practical Robert Boyle, Hooke built that Air-pump or Pneumatic Engine which has rightly been accorded a place among the constellations in the heavens, and which has recently been remodelled for the Lewis Evans Collection in memory of the most important research ever brought to a successful issue in Oxford. This engine was the *pièce de résistance* at numerous meetings of the Royal Society; and within a few years of its manufacture it became the parent of the Atmospheric Engine, whose inventor, Thomas Newcomen, had been in communication with Hooke on the subject of obtaining motive power by exhausting the air from a cylinder fitted with a piston. Among the latter's papers, not now traceable, were found lengthy notes which were prepared for Newcomen's use.[1] Hooke's humble scientific Pneumatic Engine is thus the grandparent of the Steam Engine of James Watt, and the progenitor of the greater triumphs of Industrial England. And yet there are industrialists —their name is legion—who dispute the utility of the 'pure science' by means of which their fortunes have been made.

The classic spot where Hooke grappled with the primal difficulties of making a piston fit sufficiently air-tight in a cylinder, lies on the west side of the buildings of University College in the Oxford High Street. No spot is more worthy of a memorial: indeed

[1] In an article on Newcomen's Bicentenary in the *Daily Telegraph* of 7 Aug. 1929.

a medallion to Hooke's patron, Robert Boyle, has recently been offered by Sir Robert Hadfield to mark the site, but was refused—perhaps because there is a dome to the dead Shelley on the other side of the wall.

The outlines of Hooke's life have been sketched by his contemporaries, John Aubrey, who once lodged with him, Richard Waller, and John Ward. All three were fellow-members of the Royal Society, who knew him and his circle of friends intimately. The eminent services which he rendered to Science and to the State are recorded in the Journal books of that Society, and his personal Diary has been recently acquired by the City of London; yet, since 1726, when W. Derham edited a miscellany of previously unprinted notes, no adequate attempt has been made to do justice to 'one of the most inventive geniuses that the world has ever seen'.

Like many other eminent men of science he owed much to his early education as an anatomist. No other discipline is as efficient for the simultaneous training of hand and mind, and the success of Wren, of Leonardo da Vinci, and of many another, is to be attributed to their early morphological and anatomical studies. And it is well known that persons rarely understand what they see until they try to make a drawing of it.

Although mechanics were his forte, he excelled in the making and use of optical instruments; he was an accurate observer and a good draughtsman, necessary qualities in the father of Microscopy; he became an astronomer whenever the heavens supplied an object of sufficient interest. He realized that the distance of the fixed stars might be calculated from a measure of

their change of position at the extreme seasons of the year—truly a great thought, but a measure so small as to be beyond the power of his instruments. Like Leonardo da Vinci, and unlike many of his contemporaries, he was convinced that many petrifactions were the remains of animals that had once lived. Leonardo anticipated him in this, but Hooke was the first man in the world to suggest that fossils might be used to construct a chronology of the Earth. Chemical experiments and anatomical dissections were frequent episodes in his day's work. There was nothing of the narrow specialist about him. His discovery of the Cells of which all plant tissues are built up, is at the base of the whole science of Histology, or Microscopic Anatomy. He showed the way to the study of that science by the method of cutting thin sections for examination under the higher powers of the microscope. Even the study of Bacteria has been asserted to have had its beginning with his microscope, and surely no study has been more fraught with good and evil consequences for the health of mankind than Bacteriology.

His Theory of Combustion comes as a surprise to modern chemists who read it for the first time. Often enough he realized the supreme importance of his work. He knew that it would have a great future in the history of the world, but only too often recognized the limitations to further progress. For instance, he knew how to fly, if only a light engine had been forthcoming. A remarkable prevision was his forecast of the artificial silk industry. 'A pretty kinde of artificiall stuff I have seen looking almost like transparent parchment, horns or ising-glass, and perhaps some

such thing it may be made of, which being transparent and of a gelatinous nature, and easily mollified by keeping in water, as I found upon trial, had imbib'd, and did remain ting'd with a great variety of very vivid colours, and to the naked eye, it look'd very like the substance of Silk.

'And I have often thought that probably there might be a way found out, to make an artificial glutinous composition, much resembling, if not full as good, nay better then that Excrement, or whatever other substance it be, out of which the Silk-worm wire-draws his clew. If such a composition were found, it were certainly an easie matter to find very quick ways of drawing it out into small wires for use. I need not mention the use of such an Invention, nor the benefit that is likely to accrue to the finder, they being sufficiently obvious. This hint, therefore, may, I hope, give some Ingenious inquisitive Person an occasion of making some trials, which if successfull, I have my aim, and I suppose he will have no occasion to be displeas'd.'

In what he wrote there was none of the mad vapouring of the alchemist, or the unbridled speculation of a crank who allows his imagination to govern his observations.

It is remarkable that no historian of architecture should have discussed his Buildings. A possible explanation may be that it was quite a usual thing to attribute all the work of a period to some one architect with a well-known name. Thus the work of his contemporary, Roger Pratt of Magdalen, has been attributed to Inigo Jones, and doubtless Hooke's work would have readily merged into that of Wren. Yet he

did prepare a model for a new London after the Great Fire. He did design a house for the Royal Society. He did build Montague House, the great Bedlam Hospital, and the College of Physicians, all notable works. And he must have had to do with innumerable buildings of minor importance in his official capacity of Surveyor to the City of London. Surely one day specimens of his architectural drawing, hitherto unrecognized, will turn up out of some portfolio.

To show the diversity of his work is one of the objects of these volumes. No account of Hooke would be complete without a mention of the special method by which he used to attack any new problem that might be presented to him. When a less scientifically minded researcher might remain satisfied with a single method of solving a problem, Hooke would not rest content until he had jotted down *all* the possible solutions and their variants, whether practicable or not, that presented themselves to his extraordinarily active brain. It was evidently a habit that he had acquired early, for, while still a boy he invented thirty several ways of flying. No one has been more fertile in the devising of experiments, or more systematic in tabulating possible procedures. According to Professor Robison of Edinburgh, who had an opportunity of seeing some of Hooke's manuscripts that had been rescued from the fire at the burning of Gresham College, Hooke would hastily plan out in classified form all the alternative methods that suggested themselves to him. Over this scheme he would then ponder, and use it as a means of further discovery. He found that such classifications greatly stimulated his inventive power, and he called them

his 'algebras'. He believed this method of systematizing ideas to be peculiarly his own, and he is said to have frequently spoken of other researchers, even the most eminent, as 'childishly contenting themselves with partial views of the corners of things'. A good example of such a scheme in his own autograph is preserved in the Bodleian Library. It relates to the study of the sea, or Hydrography, and a few other examples are printed in the present volume. My friend Sir Archibald Geikie gave me a delightful specimen of one of Hooke's 'algebras', entitled *Proposals for the Good of the Royal Society.*

Allurements to Members present are
Desireable Acquaintance
Delightful Discourse
Pleasant Entertainment by Experiments
Instructive Observation by Tracts
Considerable Intelligence by Letters
New Discoveries by Inventors
Solution of Doubts and Problems
An easy way to know what is already known
Liberty to Peruse ye Repository
Liberty to Peruse ye Letters and Registers
Liberty to Peruse ye Library
Liberty to Peruse ye Modules and Instruments
Liberty to be present at Mechanick, Optick, Astronomick, Chymick, Physicall and Anatomick Tryalls.

Allurement to members absent:
An Account of these once a month.

On the other hand the fact that he had noted an idea in one of his synoptic tables probably led to his claim-

ing it as his exclusive copyright. This may explain why it not infrequently happened that when some new discovery was mentioned to him, he was apt to think that he had himself made it long before, whereas he had merely considered the possibility of such a discovery, and had noted it in an appropriate place in an 'algebra'. With the onrush of other and newer interests he had not been allowed time for following out the investigation suggested.

If we were to construct an Algebra of the possible reasons for the neglect of the greatest British inventor of his day, we regret that we should have to include reflections that would not be altogether pleasant.

He was perhaps the most outstanding figure in the Royal Society. Few topics came up for consideration which he was not competent to discuss. It became quite a usual practice to refer the difficulties of other experimenters to him for solution. The Society was often dependent upon him for the agenda at its Meetings, and of him only is it recorded, that on certain occasions owing to his absence or unpreparedness there could be no meeting. He was more than a star-turn: he was the pivotal factor. If we contrast this early state of things with the congested business of scientific Society Meetings of the present day, when not only is no man indispensable, but his absence may even be to the advantage of other readers of papers, we shall form some idea of Hooke's position in the Society in 1670. His worth was eventually realized. His funeral was attended by all the members of the Royal Society in London.

But although they paid this last sign of respect, they have failed in that further duty of preserving for

later generations any portrait of their most devoted servant, or of preserving the scientific instruments by which he did so much to make their Society famous. Hooke had himself undertaken the 'collecting a repository', and Dr. Thomas Sprat has printed an inventory of the more important pieces of apparatus which it contained. Among these were Hooke's instrument for finding a second of time by the sun; his Quadrant and new instrument for taking angles by reflection; Pendulum Clocks and watches; Wheel Barometer; new kinds of Scales to examine gravity; Magnetical instruments; new kinds of Levels; a new Auger for boring; a new instrument for fetching any substance from the bottom of the sea; a new bucket; two new ways of Sounding the depths of the sea; an instrument of great height with glass windows, to be filled with water for examining the Velocity of bodies . . . by their descent; an instrument for measuring the velocity of falling bodies; new Spectacles for divers; new kinds of Hygroscopes; an Engine for measuring the Force of Gunpowder; an instrument for grinding Optic Glasses; his double Telescopes, &c. In fact the greater part of the collection consisted of instruments that had been devised by Hooke.

Among the Artificial Rarities enumerated by Grew as being in the Gresham College collection in 1681, there were Hooke's Air-pump; his large Microscope; the Weather-Clock of Wren and Hooke; Hooke's Lamp Furnace and Semi-cylindric Lamp; and his Arithmetic instrument.

Not one of these now remains.

In 1668 he was engaged in cataloguing the splendid Arundelian library of the Duke of Norfolk, which had

been secured for the Royal Society by John Evelyn, and was unnecessarily dispersed in 1830 and 1925 for sums that were far below its real value as a collection.

With the express object of focusing attention upon his remarkable achievements, we have collected all readily available notes on his various activities in the following pages. It remains but to suggest possible reasons for the undeserved neglect under which he and his work have suffered.

In the first place well-meaning biographers have probably done harm to his memory by exaggerating the circumstances of three controversies in which he was engaged. In every life of Hooke some allusion is made to his temperament. It is emphasized that he was quarrelsome, but mitigation or explanation is rarely offered. His sickly childhood should be remembered; perhaps also a digestion that was permanently impaired. Then there were the incessant interruptions to his work ordered by the Royal Society. No sooner had he hit on a discovery, and was bent on working it out, than an order went forth that Mr. Hooke was to prepare experiments for royalty, or to better the lame performance of some brother F.R.S., or to do something else that may have been yet more trivial; in any case to stop work on the 'Nobler Matters' with which he was busy.

Needless to say, he was not superhuman. No man could have accomplished what he was ordered to do in a modicum of time, and in consequence had frequently to suffer the rebuke of persons whose names are otherwise almost unknown.

Thirdly, it frequently happened that after Hooke had given a preliminary account of some of his work

at a Meeting of the Society, Henry Oldenburg, a busybody of a Secretary, would broadcast the news to other, and perhaps less occupied, workers on the Continent. This transmission of inventor's 'secrets' before publication, to the advantage of foreign workers and without the permission of the inventor, now seems scarcely honourable. There was ample justification for Hooke's temporary withdrawal from further participation in the proceedings of the Society until after Oldenburg's death in 1677.

It was natural that his principal dispute should be with Oldenburg, and he certainly had a large measure of right on his side. But his controversies with Newton, Hevelius, and Huyghens were nothing but what any scientific writer may find himself engaged in, and it may be argued that they were exceedingly helpful to his opponents. I have not seen that the controversy with Newton was unpleasantly acrimonious. We find none of the 'pettiness and ungenerosity' which Dr. Wildon Carr[1] finds when Newton neglected to reply to the letters of Leibnitz. But it is worth noting that, as a consequence, Newton decided not to publish his work on Optics until after Hooke's death, being afraid lest his claim to originality might be disputed, and it is certainly hardly fair to Hooke's memory that the coloured diffraction bands discovered by him should be everywhere known as 'Newton's Rings'.

On the other hand, Hooke was never on anything but the most friendly terms with his early friend and patron Robert Boyle, or with Moray, Wren, Wilkins, and the Fellows of the Society generally, and it is significant that his friends on the Council invited him

[1] Dr. H. Wildon Carr, *Leibnitz*, 1929.

to a seat at the Council Table immediately after Oldenburg's decease.

The friction had both bad and good results. It lessened his scientific contribution to the Society during the most active period of Hooke's life, but it showed the importance of the regular publication of the *Philosophical Transactions* with the authors' own papers.

No one regrets more than myself that even at the present day, nearly three hundred years after Hooke's birth, it is not possible to prepare an account of his wonderfully active life with all the cards on the table. Essential materials, the property of two public bodies, are still being withheld from publication, and it is not easy to conjecture the reason. They are, Hooke's own Diary, the property of the City of London, kept in the Guildhall Library, and his scientific papers and correspondence belonging to the Royal Society. While authorities at the British Museum, the Bodleian, the College of Physicians, and elsewhere have been most helpful in the advancement of learning by permitting the publication of their unique and unpublished records relating to Hooke, the librarian of the Guildhall has written that his Committee are unable to give me permission to print the Diary, while the secretary of the Council of the Royal Society, having written first to say that general permissions are not usually given, and having asked for a list of definite items which in my opinion are worthy of publication, has not been able to intimate that his Council has consented to their publication.

It is a pity, because Hooke's original papers in the archives of the Royal Society are not well arranged,

and are undergoing deterioration with age and the dirt of London. It would have been well to have illustrated these volumes with some original sketches by his own hand. No doubt there are reasons for the withholding of leave, but personally I think that any such obstacle to an endeavour to do belated justice to the memory of a member of my own University, and to rescue his manuscripts before they share the fate of his instruments, is deplorable.

Where no other acknowledgement is made, the facts now published have been mainly derived from Birch's *History of the Royal Society*, and from Derham's *Philosophical Experiments and Observations*. They should, of course, be collated with all manuscript materials still extant.

I hope at no distant date to reprint the text of Hooke's little-known *Philosophical Collections*, from which I have borrowed the more important illustrations. So that then, with *Micrographia* and Waller's volume of *Posthumous Works*, the student will have the bulk of Hooke's accessible work available for study in five volumes.

Hooke's own dedication of his *Micrographia* to Charles II contains a sentence that is well worth repeating: 'Amidst all those greater Designs, I have presumed to bring in that which is more proportionable to the smalness of my Abilities, and to offer some of the least of all visible things, to that Mighty King that has established an Empire over the best of all Invisible things of the World, the Minds of Men.'

It was the paramount importance of the work of Hooke and his contemporaries for the improvement

of manufactures and agriculture, the increase of commerce, as well as the establishing of academic teaching on a sound scientific basis, that caused in 1679 the University of Oxford to found its first independent Scientific Institution, complete with laboratory, lecture-room, library, and exhibition-gallery. This institution, the Ashmolean Museum of 1679 to 1890, now known as the Old Ashmolean, is still standing, the only science building in Britain of the great epoch of Hooke and Newton. The perishing masonry of the exterior is at present being recased with new stone at a heavy cost to the University. In the interior, the author, in his public capacity as Curator of the Lewis Evans Collection, is endeavouring to carry out Hooke's idea of a Museum or Repository for Scientific Instruments. Here are being exhibited his Pneumatic Engine, Microscope, Joints, and other inventions. But until the original lecture-room and laboratory can be cleared of the masses of Bodleian books that are there stacked in a darkness that ensures Concealment of Learning, it will not be possible in Oxford to do adequate justice to the importance of Hooke's work for the World. If these unused and unusable books could be removed to shelves accessible to students, and our historic scientific Laboratory rendered available for its proper purpose of illustrating the history of Science, great benefits would ensue. For no other purpose would a benefaction be more welcome, since if this room were available, Magdalen College has offered to transfer to it apparatus that was originally used there.

In the meantime historic instruments of value are being lost in Oxford and to Oxford.

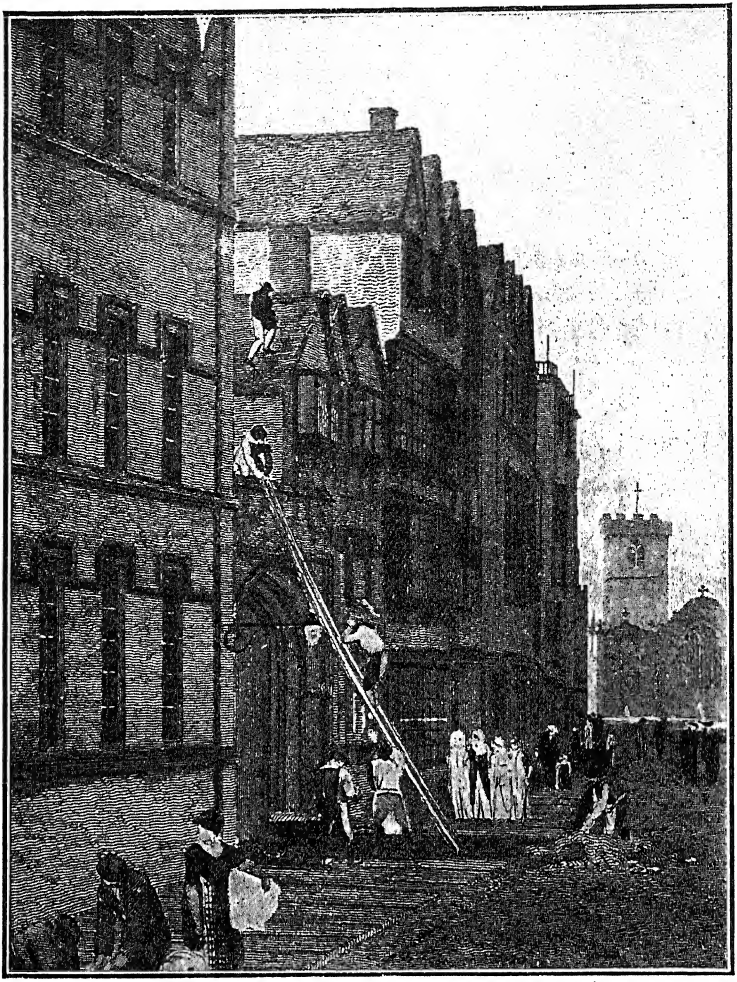
It is a pleasure to record that Christ Church, Hooke's Oxford college, has been able to contribute to the cost of the plates which illustrate this work; that the City of London should also have recently remembered Hooke's services, when they made a grant to the Fund of the Lewis Evans Collection; and that the Goldsmiths Company of London has offered the University of Oxford the sum of £500 to defray expenses that will be incurred when the old School of Natural History in the Old Ashmolean is restored to purposes akin to those for which it was opened in 1683.

R. T. GUNTHER.

THE OLD ASHMOLEAN,
OXFORD,
January 1930.

*** The work of Robert Hooke may be appropriately praised by the use of the terms applied by Walter Charleton to Sir John Cutler in 1679:

'The streams of your goodness resemble those Rivers, which, though running under ground, diffuse fertility to whole countreys & provinces through which they pass. Of this the Mechanic Lecture you founded in Gresham College for the promotion of Manual Trades, and your Anatomy Theatre are excellent examples, worthy of the imitation of good Kings and the envy of Bad. The advantages they promise are of universal concernment to the present age and cannot but extend to all in Ages to come, rendering their usefulness more & more conspicuous, the lower they descend to Posterity.'



University College. Crosse's. Three Tuns. Tillyard's.

MR. CROSSE'S HOUSE IN OXFORD WHERE BOYLE HAD HIS LABORATORY

Here Hooke worked before he became Curator of Experiments to the Royal Society.

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VOL. VII

THE LIFE OF
DR. ROBERT HOOKE

BY RICHARD WALLER

This Life was written by RICHARD WALLER, R.S.S., as an Introduction to *The Posthumous Works of Robert Hooke, M.D., S.R.S.*, which was printed in 1705 and dedicated to Sir ISAAC NEWTON, Kt., President, and to the Council and Fellows of the Royal Society of London. To this Life extracts have been added from JOHN WARD'S *Lives of the Gresham Professors*, 1740, and from AUBREY'S *Short Lives*. The additions are enclosed in square brackets.

UNDERSTANDING that it would be acceptable to several Learned and Ingenious Persons to have some publick Account given of the Life, Studies and Employments of so knowing and diligent an Inquirer into Nature, as Dr. ROBERT HOOKE is generally allow'd to have been, and who was one of the greatest Promoters of Experimental Natural Knowledge, as well as Ornaments of the last Century (so fruitful of great *Genii*) I could not well refuse that Task, which (knowing my own insufficiency for such an Attempt) I could hardly undertake, being conscious it requir'd a Person much better qualify'd with natural and acquir'd Abilities to perform it with Satisfaction; especially in so judicious and nice

an Age, more ready to find Faults than pardon Mistakes: Besides my desire has always been not to expose my self to Censure, when I might live quietly, *Studiis ignobilis otii.* But the following Papers of Dr. Hooke having been put into my Hands to be Publish'd, I was, in some manner, oblig'd to appear in Print. What Mistakes the Candid Reader may observe, in the following Relation of his Life, I hope he will obligingly pardon. In which I profess the utmost Sincerity, the greatest part of my Vouchers being either taken out his own Memorials, or from the Journals of the Royal Society.

Had Dr. Hooke prosecuted a Design which I find he once proposed to himself, my present Undertaking had been as vain as needless, for in a small Pocket-Diary of his I found these Words written.

'*Saturday April* the 10*th* 1697: I began this Day to write the History of my own Life, wherein I will comprize as many remarkable Passages, as I can now remember or collect out of such Memorials as I have kept in Writing, or are in the Registers of the Royal Society; together with all my Inventions, Experiments, Discoveries, Discourses, *&c.* which I have made, the time when, the manner how, and means by which, with the success and effect of them, together with the state of my Health, my Employments and Studies, my good or bad Fortune, my Friends and Enemies, *&c.* all which shall be the truth of Matter of Fact, so far as I can be inform'd by my Memorials or my own Memory, which Rule I resolve not to transgress.'

Accordingly I found a beginning of his Life, which tho' it affords but little satisfaction, being only con-

cerning his Childhood, yet I have here given an Abstract of what is contained in it.

Dr. ROBERT HOOKE was Born at *Freshwater*, a Peninsula on the West side of the Isle of *Wight*, on the eighteenth of *July*,[1] being *Saturday*, 1635, at twelve a Clock at Noon, and Christened the twenty sixth following by his own Father Minister of that Parish.[2]

He was very infirm and weakly, and therefore Nurst at Home, tho' his Brothers and Sisters were Nurst Abroad; and for at least seven Years his Parents had very little hopes of his Life, being often sick; all which time his chief Food was Milk, or things made thereof, and Fruits, no Flesh in the least agreeing with his weak Constitution.

For his Age he was very sprightly and active in Running, Leaping, *&c.* tho' very weak as to any robust Exercise: Was very apt to learn any thing, and after his English soon learnt his Grammar by Heart; but, as he says, with but little understanding, till his Father designing him for the Ministry, took some pains to instruct him. But he still being often subject to the Head-ach which hindered his Learning, his Father laid aside all Thoughts of breeding him a Scholar, and finding himself also grow very infirm through Age and Sickness, wholly neglected his farther Education, who being thus left to himself spent his time in making little mechanical 'Toys, (as he says) in which he was very intent, and for the Tools he had, successful; so that there was nothing he saw done by any Mechanick, but he endeavoured to imitate, and in some particulars could exceed' (which

[1] Aubrey gives 19 July as the date. [2] Curate of Freshwater.

are his own words.) His Father observing by these Indications, his great inclination to Mechanicks, thought to put him Apprentice to some easy Trade (as a Watchmaker's or Limner's) he shewing most inclinations to those or the like curious Mechanical Performances; for making use of such Tools as he could procure, 'seeing an old Brass Clock taken to pieces, he attemted to imitate it, and made a wooden one that would go: Much about the same time he made a small Ship about a Yard long, fitly shaping it, adding its Rigging of Ropes, Pullies, Masts, *&c.* with a contrivance to make it fire off some small Guns, as it was Sailing cross a Haven of a pretty breadth: He had also a great fancy for drawing, having much about the same Age coppied several Prints with a Pen, that Mr. HOSKINS (son to the famous HOSKINS, COWPER'S Master) much admired one not instructed could so well imitate them.'

These Indications of a Mechanick Genius appeared in him when very young; for by the same Paper I find that his Father died in *October* 1648, having for three or four Years before his Death been much afflicted with a Cough, a Palsy, Jaundice and Dropsy.

This is the sum of what he has left of his own Writing, by which we find him at the time of his Fathers Death, to be thirteen Years and about three Months Old.

[JOHN AUBREY, who knew Hooke well, has left the following contemporary account of him:

J. Hoskyns, the painter, being at Freshwater, to drawe pictures for . . . . Esq.) Mr. Hooke observed what he did, and, thought he, why cannot I doe so too? So he getts him chalke, and ruddle, and coale, and grinds them, and putts them on

a trencher, gott a pencill, and to worke he went, and made a picture: then he copied (as they hung up in the parlour) the pictures there, which he made like. Also, being a boy there, at Freshwater, he made an . . . . diall on a round trencher; never having had any instruction. His father was not mathematicall at all. When his father dyed, his son Robert was but . . . . old, to whom he left one hundred pounds, w^{ch} was sent up to London with him, with an intention to have bound him apprentice to Mr. Lilly, the paynter, with whom he was a little while upon tryall; who liked him very well, but Mr. Hooke quickly perceived what was to be donne, so, thought he, why cannot I doe this by myselfe and keepe my hundred pounds? He also had some instruction in drawing from Mr. Samuel Cowper (prince of limners of this age); but whether from him before or after Mr. Lilly, Qu. ?

Qu. when he went to Mr. Busby's, the schoolemaster of Westminster, at whose house he was; and he made very much of him. With him he lodged his hundred pounds. There he learn'd to play 20 lessons on the organ. He there in one weeke's time made himselfe master of the first VI bookes of *Euclid*, to the admiration of Mr. Busby, (now S. T. D.) who introduced him. At schoole here he was very mechanicall, and (amongst other things) he invented thirty severall wayes of flying, w^{ch} I have not only heard him say, but Dr. Wilkins, at Wadham coll. at that time, who gave him his *Mathematicall Magique*, which did him a great kindness. He was never a king's scholar, and I have heard S^{r}. Rich. Knight (who was his schoolfellowe) say, that he seldome sawe him in the schoole.

A^{o}. D^{ni}. 1653 he was sent to Christ Church, in Oxford, where he had a chorister's place, (in those dayes, when the church musique was putt downe), which was a pretty good maintenance. He was there assistant to Dr. Thomas Willis in his Chymistry; who afterwards recommended him to the Hon^{ble}. Robert Boyle, Esq. to be usefull to him, in his Chymicall operations. Mr. Hooke then read to him (R. B. Esq.) Euclid's Elements, and taught him Des Cartes' Philosophy. He was Master of Arts A^{o}. D^{ni}. 1663.

A^{o}. D^{ni}. 1662 Mr. Rob. Boyle recommended Mr. Hooke to be Curator of the Experiments of the Royall Society, wherein he did an admirable good worke to y^{e} Com̄on-wealth of Learning, in recommending the fittest person in the world to them. A^{o}. 1665

he was chosen Geometry Professour at Gresham College. A°. Dni. 1664 Sr. John Cutler, Kt. gave a Mechanicall lecture, 50 pounds per ann. which he read. A°. Dni. 1666 the great conflagration of London happened, and then he was chosen one of the two surveyors [Oliver, the glasse-painter, was the other] of the citie; by wch he hath gott a great estate. He built Bedlam, Montague-house, the Physitians' College, and Theatre there, and he is much made use of in designing buildings.

He is but of midling stature, something crooked, pale faced, and his face but little belowe, but his head is lardge; his eie full and popping, and not quick; a grey eie. He has a delicate head of haire, browne, and of an excellent moist curle. He is and ever was very temperate, and moderate in dyet, &c. As he is of prodigious inventive head; so he is a person of great vertue and goodness. Now when I have sayd his inventive faculty is so great, you cannot imagine his memory to be excellent, for they are like two bucketts, as one goes up, the other goes downe. He is certainly the greatest mechanick this day in the world. His head lies much more to Geometry then to Arithmetique. He is (1680) a batchelour, and, I believe, will never marie. His elder brother left one faire da. wch is his heire. In fine (wch crowns all) he is a person of great suavity and goodnesse.

'Twas Mr. Rob. Hooke that invented the Pendulum-Watches, so much more useful than the other watches.

He hath invented an engine for the speedie working of division, or for the speedie and immediate finding out the divisor. An instrument for ye Emperor of Germany, 1692–3.]

This early Propensity of his to Mechanicks was a sign of his future Excellency in such Contrivances, an admirable Facility he afterwards manifested in applying Mechanical Principles to the explication of the most difficult *Phænomena* of Nature; and I remember it has been often observed by several Persons, that whatever *apparatus* he contrived for the exhibiting any Experiment before the ROYAL SOCIETY, it was performed with the least Embarrassment clearly and evidently, to explain the present

Subject, which was a sufficient proof of his true knowledge of the Mechanical Powers, and of a method of applying them to the Explication of Nature.

How he spent the next six or seven Years of his Life I have not been particularly informed; but I understand he was for some time with Sir PETER LELY, how long I am not certain: I suppose but a short time; for I have heard that the smell of the Oil Colours did not agree with his Constitution, increasing his Head-ach, to which he was ever too much subject.

Westminster and Oxford.

It was after this that he lived with Dr. BUSBY, the late famous Master of *Westminster-School*, as a Scholar in his own House, where with more diligence he apply'd himself to *Latin* and *Greek*, in which he made a sufficient proficiency for the time, and had a competent Knowledge, and at the same time got some insight into the *Hebrew* and some other Oriental Languages. While he liv'd with Dr. BUSBY, he fell seriously upon the study of the Mathematicks, the Dr. encouraging him therein, and allowing him particular times for that purpose. In this he took the most regular Method, and first made himself Master of *Euclide*'s Elements, and thence proceeded orderly from that sure Basis to the other parts of the Mathematicks, and after to the application thereof to Mechanicks, his first and last Mistress.

From *Westminster-School* he went to the University of *Oxford* in 1653, but as 'tis often the Fate of Persons great in Learning to be small in other Circumstances,

his were but mean. I find that he was a student of *Christ-Church*, tho' not of the Foundation, but was, as I have heard, a Servitor to one Mr. GOODMAN, and took his Degree of *Master of Arts* several Years after, about 1662, or 1663.

About the Year 1655, he began to shew himself to the World, and that he had not spent his Juvenile Years in vain; for there being a Concourse at that time of extraordinary Persons at *Oxford*, each of which afterwards were particularly distinguish'd for the great Light they gave the Learned World by their justly admired Labours; he was soon taken notice of, and for his Facility in Mechanick Inventions much priz'd by them.

For the proof of his being at this time brought into the acquaintance of these great Men, I shall transcribe some Passages which I met with among his Manuscripts; and first speaking of their Philosophical Meetings at *Oxford*, he says,

'At these Meetings, which were about the Year 1655 (before which time I knew little of them) divers Experiments were suggested, discours'd and try'd with various successes, tho' no other account was taken of them but what particular Persons perhaps did for the help of their own Memories; so that many excellent things have been lost, some few only by the kindness of the Authors have been since made publick; among these may be reckon'd the Honourable Mr. BOYLE's *Pneumatick Engine* and Experiments, first Printed in the Year 1660, for in 1658, or 9, I contriv'd and perfected the Air-pump for Mr. BOYLE, having first seen a Contrivance for that purpose made for the same honourable Person by

Mr. GRATORIX, which was too gross to perform any great matter.'

The Draught of this Air-pump and all its parts, as it was after Publish'd by Mr. BOYLE, I have now by me design'd by Mr. HOOKE, and I have heard him say, he was then sent to *London* by Mr. BOYLE to get the Barrel and other parts for that Engine which could not be made at *Oxford*. But to return to some other Notes.

'The same Year I contriv'd and made many trials about the Art of Flying in the Air, and moving very swift on the Land and Water, of which I shew'd several Designs to Dr. WILKINS then *Warden* of *Wadham College*, and at the same time made a Module, which, by the help of Springs and Wings, rais'd and sustain'd itself in the Air; but finding by my own trials, and afterwards by Calculation, that the Muscles of a Mans Body were not sufficient to do any thing considerable of that kind, I apply'd my Mind to contrive a way to make artificial Muscles; divers designs whereof I shew'd also at the same time to Dr. WILKINS, but was in many of my Trials frustrated of my expectations.'

What is mention'd here of his attempts about flying, is confirm'd by several Draughts and Schemes upon Paper, of the Methods that might be attempted for that purpose, and of some contrivances for fastening succedaneous Wings, not unlike those of Bats, to the Arms and Legs of a Man, as likewise of a Contrivance to raise him up by means of Horizontal Vanes plac'd a little aslope to the Wind, which being blown round, turn'd an endless Screw in the Center, which help'd to move the Wings, to be manag'd by

the Person by this means rais'd aloft: These Schemes I have now by me, with some few Fragments relating thereto, but so imperfect, that I do not judge them fit for the Publick. But to return to his own Notes.

'About this time [1655] having an opportunity of acquainting my self with Astronomy by the kindness of Dr. WARD, I apply'd my self to the improving of the *Pendulum* for such Observations, and in the Year 1656, or 57, I contriv'd a way to continue the motion of the *Pendulum*, so much commended by RICCIOLUS in his *Almagestum*,[1] which Dr. WARD had recommended to me to peruse; I made some trials for this end, which I found to succed to my wish.

'The success of these made me farther think of improving it for finding the Longitude, and[2] *the Method I had made for my self for Mechanick Inventions*, quickly led me to the use of Springs instead of Gravity for the making a Body vibrate in any Posture, whereupon I did first in great, and afterwards in smaller Modules, satisfy my self of the Practicableness of such an Invention, and hoping to have made great advantage thereby, I acquainted divers of my Friends, and particularly Mr. BOYLE, that I was possest of such an Invention, and crav'd their Assistance for improving the use of it to my advantage.'

[1] Tom. 1. Lib. 2. Cap. 20 & 21.

[2] Waller could not meet with what is mentioned here, and in several other places of his Tracts already Printed, and of those contained in this Volume, *of a method for Mechanick Inventions*, which he somewhere calls a *Mechanick Algebra* for solving any Probleme in Mechanicks, as easily and certainly as any Geometrick by *Algebra*, and says, that by this his method he could readily determine whether any such Probleme was possible, and if so, which was the nearest and easiest way of solving it.

Invention of Balance Wheels with Springs for Watches.

'Immediately after his *Majesty's* Restoration, Mr. BOYLE was pleased to acquaint the Lord BROUNCKER and Sir ROBERT MORAY with it, who advis'd me to get a Patent for the Invention, and propounded very probable ways of making considerable advantage by it. To induce them to a belief of my performance, I shew'd a Pocket-watch, accommodated with a Spring, apply'd to the Arbor of the Ballance to regulate the motion thereof; concealing the way I had for finding the Longitude.[1] This was so well approv'd of, that Sir ROBERT MORAY drew me up the form of a Patent, the principal part whereof, *viz.* the description of the Watch, so regulated, is his own hand Writing, which I have yet by me: the discouragement I met with in the management of this Affair, made me desist for that time.'

So far this Paper. In confirmation of what is abovesaid, I met with a Draught of an Agreement between the Lord BROUNCKER, Mr. BOYLE and Sir ROBERT MORAY, with ROBERT HOOKE Master of Arts to this purpose, that ROBERT HOOKE should discover to them the whole of his Invention to measure the parts of Time at Sea as exactly and truly as they are at Land by the *Pendulum* Clocks invented by Monsieur HUYGENS; That of the Profits to be made thereby not exceeding 6000*l.* ROBERT HOOKE was to have $\frac{3}{4}$ of whatever was made more of it, not exceeding 4000*l.* ROBERT HOOKE was to have

[1] Dr. DERHAM notes that he had seen engraved upon a double balance watch presented to CHARLES II, the inscription 'ROBERT HOOK INVEN. 1658, T. TOMPION FECIT 1675'.

$\frac{2}{3}$ of the rest: if more could be made of it, he was to have the $\frac{1}{2}$, and ROBERT HOOKE to be publickly owned the Author and Inventor thereof. This is the sum of one Draught; there are indeed some others which differ only in the division of the Profits, which it is needless here to trouble the Reader with. In pursuance of this Design there were several Papers drawn up, *viz.* The Draught of an Act of Parliament to oblige all Masters of Ships to pay so much *per* Tun for the use of this Invention, as also of a Warrant to be granted by the *King* to ROBERT HOOKE, M.A.[1] &c. for a Patent for the sole use of the said Invention for fourteen Years, and sign'd by His Majesty's Command, WILLIAM MORRICE. I have some other Papers which are unnecessary to be here mention'd.

Thus far the Matter then proceeded, and how it came to stop here may be justly wondred; but to give the Reader the best satisfaction I can in this matter, I shall transcribe a Paragraph out of the Postscript to HOOKE's Treatise of *Helioscopes* Printed 1676.

'This Treaty with me had been finally concluded for several Thousand Pounds, had not the inserting of one Clause broke it off, which was, *That if after I had discover'd my Invention about the finding the Longitude by Watches (tho' in themselves sufficient) they, or any other Person should find a way of improving my Principles, he or they should have the benefit thereof during the term of the Patent, and not I.* To which Clause I could no ways agree, knowing 'twas easy to vary my Principles an hundred ways; and 'twas not

[1] The degree of M.A. was conferred on him in 1663 by the favour of the Chancellor of Oxford, Sir EDWARD HYDE.

improbable, but there might be some addition of conveniency to what I should at first discover, it being *facile inventis addere*; and judging it unreasonable to be depriv'd of the benefit of my Inventions, in themselves sufficient, because others might vary them, or any other ways improve them, of which it was very probable they would have no thought if they had not the advantage of being instructed by my Discovery, it having been hid some Thousands of Years already; as indeed the effect hath made evident and certain, there having been nothing done by any Body else upon that matter [for these fifteen years. Upon this point our treaty was broken off, and I concealed the further discovery of any of the other more considerable parts of my inventions for the regularity of time keepers; as hoping I might find some better opportunity of publishing them, together with my way for finding the longitude of places; for which I hoped to have had some benefit for all the labour, study, and charge I had been at for the perfecting thereof &c.']

There is more in the same place worth the perusal, which, for brevity, I omit.

Dr. Hooke suffering this Invention to lie undiscover'd to the last, gave some Persons cause to question whether he was ever Possessor of it, and to doubt whether what in Theory seem'd very promising, wou'd answer when put to the Test of Practice; others indeed more severely judged, that it was only a kind of boasting in him, to assert he knew that which had not yet been perform'd, tho' attempted by many. However the matter is, it is certain he persisted in the affirmation to the last, and not many

Weeks before his Death, told me and other Persons, that he knew a certain and infallible method to descover the true place of a Vessel at Sea, as to its East and West distance from the Port departed from: Whether by Watches, or other Time-keepers, or by any other ways, I know not, tho' indeed by what is before mention'd, it should seem to be by Watches, for the improvement of which he made many Trials, and read several Discourses.

However this matter produc'd the discovery of that most useful and practicable method of regulating Pocket-watches by a spiral Spring, apply'd to the Arbor of the Ballance as they are now made without any considerable addition since; the History of which, as I have heard it from himself and find publish'd, is thus.

In Discourse once he told me, that about the Year 1660, he having shewn a Movement so regulated to the Lord Brouncker, &c. as is above related, Monsieur Huygens having for some time apply'd himself to invent several ways to regulate Time-keepers by the correspondence he held with Mr. Oldenburgh, among other matters had notice of this, for which there was afterwards an application made to procure a Patent. This indeed is possible, but whether it were so or not I cannot determine. That Mr. Hooke had many Years before (Huygens mention'd it) discover'd the Invention is certain, by what is related in the History of the Royal Society among several new Inventions, in these words, *There have been invented several kinds of Pendulum Watches for the Pocket, wherein the motion is regulated by Springs*, &c.

Now tho' this does not mention the Springs being spiral or fastened to the Arbor of the Ballance, yet it appears it was so by what is related above; and a Passage I have seen in a Letter from Sir ROBERT MORAY to Mr. OLDENBURGH, dated *Oxon Sept.* 30, 1665, clears it, in which are these words. 'You (meaning OLDENBURGH) will be the first that knows when his (that is HUYGENS's) Watches will be ready, and I will therefore expect from you an account of them, and if he imparts to you what he does, let me know it; to that purpose you may ask him if he doth not *apply a Spring to the Arbor of the Ballance*, and that will give him occasion to say somewhat to you; if it be that, you may tell him what HOOKE *has done in that matter, and what he intends more.*' Altho' I cannot be assur'd what OLDENBURGH wrote to Monsieur HUYGENS, yet it is probable their intimacy procur'd what he knew; and it is evident that HUYGENS' discovery of this was first publish'd in the *Journal des Scavans*, and from thence in the *Philos. Transact.* for *March* 25th, 1675, about ten Years after that Letter of Sir ROBERT MORAY'S, and near fifteen after HOOKE'S first discovery of it.

To this I shall add what Mr. OLDENBURGH has printed, *Philos. Transact.* No. 118. ''Tis certain the describer of Helioscopes (meaning HOOKE) some Years ago caus'd to be actually made some Watches of this kind; which (indeed he there says) were unsuccessful.' Which whether so or not, I cannot learn, so many Years after, tho' I am inclin'd to think that Expression proceeded from Passion, the Invention and Principle of HOOKE'S and HUYGENS'S being both the very same as are now us'd.

To this of Mr. OLDENBURGH, Mr. HOOKE made his Reply in a Postscript to his *Lampas*: In rejoinder to which OLDENBURG Printed a Declaration of the Council of the ROYAL SOCIETY,[1] to testify his faithfulness in managing the Correspondence of the Society; but it is observable that in this place there is no contradiction to HOOKE's being the first in that Invention.

It cannot be deny'd but that Mr. HOOKE was frequently desir'd to perfect his Inventions about Watches and Time-keepers, which, when urg'd, he as often promis'd, and when any new Contrivance was by any Person produc'd, he then shew'd something of his own, either the same, or excelling it, a Proof he had try'd the same before. 'Particularly when on the *9th* of *August*, 1666, Mr. MERCATOR shew'd to the Society a Watch of his Invention, representing the Æquation of Time to the approbation of the Company. Mr. HOOKE at the same time produc'd a new piece of Watch-work of his own Contrivance to measure Time exactly both at Sea and Land, of which he was desir'd to bring in the Description, which, tho' promis'd, was, as I think, never done.'

It must be confess'd that very many of his Inventions were never brought to the perfection they were capable of, nor put in practice till some other Person either Foreigner or of our own Nation cultivated the Invention, which, when HOOKE found, it put him upon the finishing that which otherwise possibly might have lain 'till this time in its first Defects: Whether this mistake arose from the multiplicity of his Business which did not allow him a sufficient

[1] *Philos. Trans.* No. 129, p. 749, printed in full below, p. 47.

time, or from the fertility of his Invention which hurry'd him on, in the quest of new Entertainments, neglecting the former Discoveries when he was once satisfied of the feazableness and certainty of them, tho' there wanted some small matter to render their use more practicable and general, I know not, and whether this was the Case in the present Subject: But this I suppose may be an undoubted Truth, the spiral Springs were not apply'd generally to regulate Watches, 'till after this Dispute with HUYGENS.

[On this subject Ward adds that he cannot in justice to Mr. Hooke, but take notice of the account given of it by a late French writer, which is as follows. "The movement of watches was formerly regulated only by the balance, and the force of a large spring, which by unwinding itself rendered the motion swifter or slower. But upon the 7 of July 1674, the abbot de Hautefeuille of Orleans communicated to the members of the royal academy the method of regulating the motion of the balance of watches, by means of a small straight spring, fixed at one end to the edge of the plate, and which was fastened at the other end to the edge of the balance, and regulated its motion, performing the office of a pendulum." After this, "Mr. Huygens published a letter in the *Journal des Scavans*, of the 25 of February 1675, *concerning a new invention of very exact and portable watches*, wherein he pretended to be the author of that discovery, and accordingly obtained a licence from the king to make the advantage of it; but Mons. de Hautefeuille having opposed its being registered, and proved that he was the first inventor, Mr. Huygens did not reap any benefit from

that licence."[1] The same writer afterwards acquaints us with the difference between this invention of Mons. de Hautefeuille, and the improvement made to it by Mr. Huygens. What he sais, is to this effect: "The abbot de Hautefeuille discovered the admirable secret of regulating the vibrations of the balance of watches by means of a small straight spring made of steel, and communicated it to the royal academy of sciences in 1674, *etc.* which Mr. Huygens afterwards brought to perfection by his spiral spring." By this representation one would be led to think, that the whole invention of pendulum watches was intirely owing to those two gentlemen. And could this writer have been ignorant of Mr. Hooke's claim to it long before either of them, his account of the matter might be thought to have proceeded from want of better information. But he has in the same treatise undertaken to abridge two books, writen by Englishmen upon clocks and watches, who both give the invention of pendulum watches with a spiral spring to Mr. Hooke. The author of one of these books was Mr. Henry Sully, an English watch maker, who lived many years at Paris, and wrote in the French language. He speaking of those watches sais: "It is an admirable invention, of which Dr. Hook, formerly professor of geometry in Gresham college at London, was the inventor."[2] But no notice is taken of this by the abridger. The other book refered to above is

[1] *Traité general des horloges, par le R. P. Dom. Jacques Allexandre, religieux Benedictin de la congrégation de Saint Maur, pag.* 24, *à Paris* 1734. en octav.

[2] *Regle artificielle de tems, par H. Sully,* chap. 1, p. 14, en not. *à Paris* 1717. en octav.

Dr. Derham's *Artificial clock maker*, who in his tenth chapter, which bears this title, *Of the invention of those pocket watches, commonly called pendulum watches*, attributes the invention both of the straight and spiral spring to Mr. Hooke; and likewise describes the difference between his watches, and those made afterwards by Mr. Huygens. "The watch of Mr. Huygens (sais he) agreed with Dr. Hook's in the application of the spring to the balance; only Mr. Huygens's had a longer spiral spring, and the pulses or beats were much slower, *etc.*" But all the abridger takes from thence relating to Mr. Hooke, after giving the title of the chapter, is this: "Dr. Hooke was the inventor of them. He contrived also different ways of regulation, one of which was made with a load-stone, another with a very small and straight spring, one end of which was fastened to the balance, and the other to the plate, and made its vibrations backwards and forwards with the motion of the balance. He had likewise several other contrivances of this nature, as the watch with two balances, each of which had but one pallet, *etc.*" Mention is here made of the straight spring, but not of the spiral one, tho both are shewn to have been Mr. Hooke's invention by Dr. Derham. So that I dont see, with what reason this writer could before ascribe the former to Mons. de Hautefeuille, and the latter to Mr. Huygens; or indeed how to reconcile what he there relates concerning Mons. de Hautefeuille, with what he sais here relating to Mr. Hooke from the treatise of Dr. Derham.]

I have been the more particular in this matter, that I Might, as far as I was able, assert the Inven-

tion to the true Author, and suppose I have wrong'd no Person. They that require more of this Subject may consult the Philosophical Transactions, and HOOKE's Tracts in the places before quoted: I have in this brought all that relates to this Question together, that the Reader may the better understand the whole matter, tho' thereby I have disorder'd the series of his Life, and order of Time.

But to return (from this Digression, which, to make it more plain, I have enlarg'd upon) to *Oxford*, I find that 1655, or 6 there were many curious Experiments, Observations and Inquiries made, and Instruments for those purposes contriv'd, as particularly the *Barometer*, of which he says, the first occasion of the Invention was a Suggestion of Sir CH. WREN in order to find whether the Hypothesis of DES CARTES for giving the Reason of the Tides from the pressure of the Moon upon the Air in its passage by the Meridian, were true or not. At this time I have heard Mr. HOOKE say, it was first observ'd, that the height of the *Mercury* in the *Barometer* did not conform itself to the Moon's motion, but to that of the different Gravitation of the Air, as has been since sufficiently verified. Yet in a *French* Treatise Printed at *Paris*,[1] several Years after this Observation at *Oxford*, the discovery of the Gravitation of the Air is attributed to Monsieur PASCAL deduced from several Experiments, made about the Year 1650, at *Clermont* in *Auvergne* by Monsieur PERIER, at *Paris* by others: And at *Stockholm* by Messeures DES CARTES and CHANUTE; which if it be, as is there related, and the Inferences from that Experiment

[1] *Traitez de l'Equilibre de liqueurs*, &c. 1664.

such as are in the same Tract mentioned, 'tis strange they should not have been apply'd to the use of so beneficial an Instrument sooner, which I do not find it was till after this Observation at *Oxford*.

By the persuasion of Dr. SETH WARD afterwards Bishop of *Salisbury*, about 1656 he apply'd himself more particularly to the Study of Astronomy, and about 1658, or 59, he says thus, 'I contriv'd several Astronomical Instruments for making Observations both at Sea and Land, which I afterwards produc'd before the ROYAL SOCIETY.'

Some of these, I suppose, are the Instruments hereafter mention'd in his Astronomical Lectures, where I have endeavour'd to retrieve as many as I could, partly from some rough Draughts, partly from old Modules, and some from the verbal Descriptions where both those helps were wanting; in which how I have succeeded, is left to the candid Readers Judgment.[1]

Much about this time (as he says) he contriv'd the '*Circular Pendulum*', and the use of it for continuing the motion of another *Pendulum*, which he afterwards shew'd to the ROYAL SOCIETY in 1663; about which time, and afterwards, there are several particulars relating to the *Circular Pendulum* enter'd in the Journals as his: A Movement to this purpose; is describ'd in his *Animadversions on Hevelius's Machina Cælestis*, pag. 68, Printed 1674.[2]

[1] *Posthumous Works*, p. 500, &c.

[2] See DERHAM, *The artificial Clockmaker*, 1734, p. 97.

Curator of the Royal Society.

In the Year 1660, the most Illustrious ROYAL SOCIETY was founded, for a full account of which, and its Institution, the Reader is referred to the Right Reverend and Learned Dr. SPRAT'S History thereof, Publish'd 1667. I shall only observe the Occasion and Time when Mr. HOOKE was introduc'd into their Service as *Curator*. Soon after the beginning of the ROYAL SOCIETY, *viz.* about *April* 1661, a Debate arose in the Society, occasion'd by a small Tract Printed in 1660, about the cause of the rising of Water in slender Glass Pipes, higher than in larger, and that in a certain proportion to their Bores; this Discourse was wrote and Publish'd by HOOKE; the Explication of which difficult *Phænomenon* made him the more regarded. The sum of his Reasonings upon this Subject he Publish'd afterward, *Micrography Observ.* the 6th, in which there are several very curious and then new Remarks and Hints; as to the Nature of Fluidity and Gravity, which last is farther prosecuted in his Treatise of Springs, with other excellent Subjects, to which the Inquisitive are referr'd for a more ample satisfaction.

This, together with his former Performances, made him much respected by the *R. Society*, and on the fifth of *November* 1662, 'Sir ROBERT MORAY propos'd a Person that was willing to be entertain'd as a *Curator* by the *Society*, offering to furnish them every day when they met, with three or four considerable Experiments; which Proposition was unanimously receiv'd, Mr. HOOKE being nam'd to be the Person; and accordingly the next Day of their meeting on the

twelfth of *November* he was unanimously accepted and taken as *Curator*, with the Thanks of the *Society* order'd to Mr. BOYLE for dispensing with him for their use, and order'd that Mr. HOOKE should come and sit among them, and both bring in every Day three or four of his own Experiments, and take care of such others as should be recommended to him by the *Society*.'

From this time the *Societies* Journals gave sufficient Testimonials of his Performances, all which would be too many to particularize here, therefore I shall only touch upon some of the chief, as the Experiment of breaking Glass-Bubbles inward, the Air contain'd in them being rarify'd by heat in their blowing, and so hermetically sealing them whilst hot; which Bubbles were observ'd at a certain degree of Tension, both in the distending them whilst blowing, and in their contracting as they cool'd, to yield a smart sound, several of these in cooling would break inwards with a brisk noise, tho' others broak without any noise, upon which the Experimenter made several Remarks.

Many Experiments were made to explicate the Nature and Quality of the Air, *viz.* as to its Gravitation, its different Effects when Rarify'd, Condens'd and Natural, with its use as to the Life of Animals, and maintaining a lucid Flame, or cause the Dissolution of Bodies by Fire, a live Animal and Lamp being inclosed together in a Receiver, shew'd the *Pabulum vitæ* and *flammæ* to be much the same: At which time also he try'd how long the same Air would serve for breathing. This leads me to remember that noble Experiment made by him of keeping a Dog

alive, his *Thorax* being laid open, by blowing fresh Air into his Lungs, of which a particular Account is given in the *History of the Royal Society* [printed on p. 215] which plainly shews the use of the Air, and difference between venal and arterial Blood.

He shew'd what addition of weight is given to Fluids, by ascending and descending Bodies in them. The different Specifick weight of Hot and Cold Water, with the uses to be made thereof in heating large quantities of Water. Of the difference of Ice and Water, with the Refraction of other Fluids, by an Instrument describ'd in the Preface to his Micrography.

Experiments and a Contrivance to shew the Force and Velocity of Bodies falling from several heights, weighing Bodies at several heights. *Pendulums* of two hundred Foot long. The difference of the *Barometer* at several heights. Experiments to improve Land Carriage. Methods of conveying secret and quick Intelligence.

Instruments to measure time exactly. To observe a second Minute by the Sun or Stars. To try the strength of Gun-powder, and several others, particularly an Engine to cut down the Teeth of Watch Wheels more exactly than can be done by the most expert Hand, an Invention now of constant use.

About this time he fix'd the Standard for the *Thermometer* from the Point of Freezing; and contriv'd a way to make the motions of the *Barometer* more sensible, which is since with farther Improvements, Publish'd in the *Philosoph. Transact.* No. 185, p. 241.

In *Feb.* 1663/4, he contriv'd a way to supply fresh Air to the Urinator under the Diving Bell by a Chain of Buckets and a Leaden Box for his Head, when he went out of the Bell to be supply'd with fresh Air from the Bell, *&c.*

At this time he shew'd Experiments of the dilating of Glass and other Bodies by Heat.

In *July* 1664, he produc'd an Experiment to shew the number of Vibrations of an extended String, made in a determinate time, requisite to give a certain Tone or Note, by which it was found that a Wire making two hundred seventy two vibrations in one Second of Time, sounded *G Sol Re Vt* in the Scale of all Musick. Other Experiments were made of the division of a Monochord, which I omit.

About this time many Experiments were made of the Velocity of Bodies sinking and rising in Water, in order to ascertain that Contrivance, which was after made publick, of sounding the Seas depth with the Sounding Ball, which is too well known to insist on it.[1]

At several Meetings of the *Society* in 1663, and 4, he produc'd his Microscopical Observations, and read the Explications and Discourses made upon them, which were after publish'd in his *Micrographia*, at the beginning of the Year 1665. In which Book, I suppose, it will hardly be deny'd, that there are more excellent Philosophical Discoveries and Hints, than in most extant of its bulk: The Book itself being well known, I shall only observe that there are describ'd in it several sorts of Microscopes, with the ways of using them. The Baroscope, Hygroscope,

[1] *Philos. Trans.* No. 9, p. 147, & No. 24, p. 439.

an Instrument to graduate Thermometers, an Engine to grind Optick-glasses, an Instrument to measure the Refraction of Liquors, *&c.* I remember Mr. MARSHAL when he desir'd the *Societies* Approbation of his new Method of grinding Spectacles and other Optick-glasses, own'd he had the first intimation of it from a hint of Mr. HOOKE's in this Book about the Polishing many very small Microscope Object-glasses at once.

A more particular Account of this Book is extant in the *Philosoph. Transact.* No. 2, p. 29, and to shew the Esteem Foreigners had of it, I shall refer the Reader to the account given of it in the *Journal des Scavans* for the Month of *December* 1666. In this the Journalist speaks with great Respect of the Author, and Esteem for the Work itself, observing the vast number of curious Remarks made therein concerning the improvement of the other Senses, as well as that of seeing: Observations of Colours and Light, the Moon, Stars, Reflexion, Inflection, *&c.* concluding (after having mention'd several) that the Book contains more than can be taken notice of in an Extract.

Cutlerian Lectures.

In the beginning of *June* 1664, Sir JOHN CUTLER having intimated his Design to some Members of the *Society* of founding a Mechanick Lecture, with a Yearly Gratuity of fifty Pounds, on the twenty second of the same Month several Members met to confer about the manner of setling that Lecture, and on the ninth of *November* following, it is enter'd in the Journals to this purpose; 'Sir JOHN CUTLER

having founded a Lecture, and settl'd an Annual Stipend upon ROBERT HOOKE, M.A. of fifty Pounds during Life (entrusting the President, Council and Fellows of the said *Society* to direct and appoint the said Mr. HOOKE as to the Subject and Number of his Lectures) the *Society* order'd several of their Members to wait upon Sir JOHN CUTLER, with their Thanks for his particular Favour to a worthy Member, and for that Respect and Confidence he hath hereby exprest towards their whole Body, *&c.*'

'On the twenty seventh of *June* 1664, it was voted that at the first Opportunity Mr. HOOKE should be put to the Scrutiny for the *Curator's* place by Office; on the twenty third of *November* following he was propos'd as a *Setled Curator* of Experiments; and on the eleventh of *Jan.* 1664–5, elected and made *Curator by Office* for Life, with an additional Salary to Sir JOHN CUTLER'S Annuity.'

Gresham Professorship and the Plague.

[On March 20, 1664–5, he succeeded Dr. Dacres as Geometry Professor in Gresham College, and within a few months the valuable Colwall collection of natural and artificial rarities came under his care.]

At this time he read several Astronomical Lectures, some of which are publish'd in this Volume, and invented many Instruments, particularly his Quadrant with a Ruler on the Limb; an Instrument to measure the Velocity of the Wind, and repeated the Experiment of the Vibrations of a Pendule two hundred Foot long. The first proposal for the Weather-Clock was then offer'd upon the Description of one made by Sir CHRISTOPHER WREN. The

Experiment was made and account given of the suspension of the Mercury to seventy five Inches in the Tube, which, with some additions, is Printed in this Volume. From this time he brought in almost at every Meeting, Experiments, Observations, Schemes of new Instruments and Inventions, or something considerable to the advancement of Knowledge, and very frequently read his *Cutlerian* Lectures, many whereof he publish'd, the most material parts in his Tracts Printed at different times, in Quarto, call'd *Lectures and Collections*, &c. comprizing compendiously in one continu'd Discourse, the chief Matters and Subjects handled in several Lectures.

[A person of less abilities, than he, would have found it difficult to discharge the duty of these several imployments at once with reputation; but so great was his industry, so accurate his skill in every province he undertook, and his mind so fruitful of new inventions, that he went thro them all with general approbation.]

Thus the generous Ardor with which the ROYAL SOCIETY was inspir'd, continu'd till the Year 1665, when, by reason of the great Mortality then reigning, they were oblig'd to desist and break up their Weekly Meetings till the fourteenth of *March* 1665/6, when, upon Summons, they met again.

[The London meetings of the Society ceased on the 28 of June; tho their business was not on that account wholly laid aside, the *Philosophical transactions* for the months of November, December and January being printed at Oxford, and at London again for February that year. Before Mr. Hooke left London, he shewed his sagacity with respect to

the cause and nature of that distemper among us, in a letter written from Gresham college to Mr. Boyle, in which he sais: "I cannot, from any information I can learn of it, judge what its cause should be; but it seems to proceed only from infection or contagion, and that not catch'd but by some neer approach to some infected person, or stuff. Nor can I at all imagine it to be in the air, tho yet there is one thing, which is very differing, from what is usual in other hot summers, and that is a very great scarcity of flys and insects. I know not whether it be universall, but it is here at London most manifest. I can hardly imagine, that there is a tenth part, of what I have seen other years."[1] How far this sentiment of Mr. Hooke has been since proved and confirmed by a very learned and celebrated physician, is well known to the world.[2]]

In this Interim the Members retir'd to several Places in the Country, and Mr. HOOKE attended Dr. WILKINS, and some other ingenious Gentlemen [Sir John Petty] into *Surrey*, near *Banstead Downs*,[3] where several Experiments were made during this Recess, an account of which was after brought into the *Society*.

At one of the first Meetings, after they came together again, 'Mr. HOOKE produc'd a very small Quadrant for observing accurately to Minutes and Seconds, it had an Arm moving on it by means of a Screw lying on the Limb of the Quadrant'; this is all the account I find of it. Possibly this was the first ever made after that manner, tho' it is now

[1] Dat. 8 July 1665. *MS.* Mr. Miles. [2] Mead *De peste*, p. 97, *etc.*
[3] Durdans, a seat of the Earl of BERKELEY near Epsom.

sufficiently known and practis'd: A large one of this sort, and of all its parts, with the rest of the *apparatus* and manner of using it, is at large publish'd by the Inventor, *Anno* 1674, in his *Animadversions on* HEVELIUS's *Machina Cælestis*, pag. 54, in which Book also several other ingenious Contrivances, Instruments and Inventions are mention'd.

'*May* 23d, 1666. There was read a Paper of Mr. HOOKE's explicating the Inflexion of a direct motion into a Curve by a supervening attractive Principle, which was order'd to be Register'd. The Discourse contain'd therein is' [printed on pages 265–8 below].

'*Aug.* 1st, 1666, he read his Observations of the Comet in 1664, after Printed among his Tracts, and call'd *Cometa.* The same produc'd a certain Contrivance to shew that the Circular Pendulum was made of two strait Lines crossing each other, *&c.*' and about the same time his Instrument to take the distance of the Stars from the Moon, the one Object seen direct, the other by Reflexion, this is publish'd in his Book, pag. 503.

The Fire and Hooke's Architectural Employments.

The dreadful Conflagration of a great part of the City of *London* happening in the beginning of *September* 1666, brought another great hindrance to the *Societies* Proceedings; so that they were oblig'd to remove their usual place of Meeting from *Gresham College* to *Arundel* House in the *Strand*, where, by the favour of the then Duke of *Norfolk*, they prosecuted their former Inquiries, their first Meeting at *Arundel* House being on the ninth of *Jan.* 1666/7.

'On the nineteenth of *Sep*. 1666, he produc'd a Module he had design'd for the Rebuilding of the City, with which the *Society* were very well pleas'd, and Sir JOHN LAURENCE the then late *Lord Mayor*, address'd himself to the *Society*, expressing the present LORD MAYOR'S AND ALDERMEN'S liking thereof, as also their desire that it might be shewn to his MAJESTY, they preferring it far before the Model drawn up by the City Surveyor.'

What this Model was, I cannot so well determine, but I have heard that it was design'd in it to have all the chief Streets as from *Leaden-Hall* corner to *Newgate*, and the like, to lie in an exact strait Line, and all the other cross Streets turning out of them at right Angles, all the Churches, publick Buildings, Market-places, and the like, in proper and convenient places, which, no doubt, would have added much to the Beauty and Symmetry of the whole. How this came not to be accepted of I know not, but it is probable this might contribute not a little to his being taken notice of by the Magistrates of the City, and soon after made Surveyor.[1]

[But the reason why no further notice was taken of this model afterwards, was very probably, because that of Dr. Wren had been then delivered to his majesty, and by him laid before the council, as was shewn in his life; tho, as the doctor had not opportunity to communicate his either to the royal society, or the city, before it was sent to the king, neither of them probably at that time had seen it.]

[1] As examples of HOOKE'S skill as an Architect we may quote the new Bethlem Hospital, the College of Physicians, and Montague House, which became the British Museum. In 1691 he planned Alderman ASKE'S Hospital at Hoxton.

The Rebuilding of the City, according to the Act of Parliament, requiring an able Person to set out the Ground to the several Proprietors, Mr. HOOKE was pitch'd upon, and appointed *City-Surveyor* for that difficult Work, which being very great, took up a large proportion of his Time, to the no small hindrance of his Philosophical Disquisitions.

In this Employment he got the most part of that Estate he died possessed of, as was evident by a large Iron Chest of Money found after his Death, which had been lock'd down with the Key in it, with a date of the Time, by which it appear'd to have been so shut up for above thirty Years: In this was contain'd the greatest part of what he left behind him, which was to the value of many thousands in Gold and Silver. That he might by this place justly acquire a considerable Estate, I think cannot be deny'd, every particular Person after the Fire being in haste to have his concerns expedited; so that as I have been inform'd he had no Rest early and late from Persons soliciting to have their Grounds set out, which, without any Fraud or Injustice, deserv'd a due recompence in so fatiguing an Employ.

Oct. 31, 1666. He shew'd his *inclining Pendulum*, with the uses thereof, to regulate the motions of a Clock as exactly as a long one.

On the 9th of *Jan.* 1666/7, he was order'd to prosecute his Observations of the Earth's *Parallax* formerly by him propos'd: A large Account of the Result of his Observations therein were after Printed in his *Attempt to prove the motion of the Earth* 1674, being the first of his *Cutlerian Lectures* publish'd.

On the 6th of *Feb.* following, he produc'd his new

Lamp contriv'd so as to supply the Oil in equal quantity as it wastes, that it may never rise too much or too little, the farther Description and Explication of which, with many curious Remarks, were Publish'd 1677, and intitl'd *Lampas*, or *Descriptions of some Improvements of Lamps and Water-poises*, &c.

Feb. the 28th. He first produc'd his *Reflecting Telescope*, which is describ'd with the Reason of the Principle, with some other Instruments in his Treatise of *Helioscopes*, printed 1676.

On the 17th of *June* 1667, and afterwards he read large Discourses of the Causes, Powers and Effects of *Earthquakes*, affirming the great Hills and Mountains in the World to have been raised by them, of which Subject he at several times afterwards made very many Discourses and Lectures, the most part of which are collected together in his [*Posthumous Works*], beginning at p. 279.

In *July* 1667, he try'd several Experiments upon himself in an *exhausted Receiver*, big enough to contain a Man, I think the only Experiment of that kind ever try'd.

At this time he contriv'd a *Micrometer* of less Charge and Difficulty than that invented by Mr. GASCOIN with Screws; this, I suppose, is publish'd in his *Posthumous Works*, p. 498.

Dec. 26, 1667. He brought in a farther Description of a *Sea Barometer*.

Jan. the 16th 1667/8, he produc'd 'his new Contrivance of promoting the Vibrations of Pendules, so as to prevent all Checks, which he affirmed had not been provided against by any Contrivance to that time.'

Apr. 9. 1668. He produc'd two Instruments to promote the sense of Hearing.

May the 14th He shew'd an Experiment of the penetration of Liquors in Oil of Vitriol and fair Water.

About this time he produc'd many other Experiments and Inventions, which I omit, and shall only observe, that there being several Discourses about the measuring of a Degree of the Earth, he propos'd divers Methods of performing it, and invented several Instruments; and as is enter'd in the Journal, *Oct.* 28, 1669, Mr. HOOKE was of Opinion, *That one of the exactest ways of measuring, was by making accurate Observations of the Heavens to a second, by a Perpendicular Tube, and then to take exact distances by Angles to a second also*, which I take to be the Method observ'd by the *French* not long after, as may be seen by a particular Treatise of it publish'd by Monsieur PICART, as likewise by what DUHAMEL says in his History of that Society, p. 98, to which the curious are refer'd. I find also by some Notices and loose Papers of our Curator, that he invented a sort of travelling Calesh for this purpose, which should describe upon a Paper, not only the Mensuration of the way gone over, but the several Ascents and Descents, together with the turnings and windings of the Calesh, or the Points of the Compass upon which the Person travell'd with other Contrivances, which I know not by what misfortune, were never put in practise. There were also other Methods for measuring a Degree propos'd to be made in St. *James's* Park on the Canal, which also had the like fate of not being prosecuted.

In *Jan.* 1669/70, He first propos'd a drop of Mercury for an universal Standard, which is more at large describ'd, in his Posthumous Works, p. 472. And in *April* shew'd an Experiment with a solution of Copper to represent the appearance of Clouds and other aerial Meteors, by dropping into it several Salts, *&c.* and at the same time shew'd the use of introducing the Species into a dark Room for Painting, and contriv'd a Box for that purpose.

In *March* 1671, 'he shew'd several Experiments to explain the Nature and Cause of *Gravity:* Particularly on the 9th an Experiment was made, in which some Flower put into a void shallow Glass with a large sloping brim, and a pretty tall Foot was made to rise and run over like a fluid, by the knocking on the edge of the Glass, and also by the forceably moving of ones Finger round the edge of the same. Leaden Bullets also being put into this Glass, did, by knocking, move it like a fluid.—This was propos'd to consider what might be the cause of Gravity, and suggest an Hypothesis to explicate the motion of Gravity by, *&c.*'

These, and several other Experiments, he shew'd to explain Natural Bodies and Actions, in some of which I have been the more particular out of a hope these hints may excite some inquisitive Person to proceed farther in such Inquiries.

This same Year several Discourses and Papers past between the Learned Mr. NEWTON and Mr. HOOKE concerning *A new Theory about Light and Colours,*[1] which being now so generally known, I shall not farther insist on.

[1] *Phil. Trans.*, 80, p. 3075.

About this time he made a Proposition for perfecting all sorts of Optick-glasses, the secret of which was deliver'd in an Anagram to the President my Lord BROUNCKER.

The Dispute with Hevelius.

Not long after this time began that unhappy Dispute between Monsieur HEVELIUS and HOOKE concerning the preference of Plain and Telescopical Sights for Astronomical Instruments, which, as I can collect, was thus occasion'd. Mr. HOOKE, by means of Mr. OLDENBURGH, had recommended to Monsieur HEVELIUS the Application of Telescopick Sights to his exquisitely contriv'd and elaborated Instruments, affirming that by them an Angle might be taken to a much greater niceness than with plain Sights, and gave them a short, but as he thought a sufficient information of the manner of applying them to the Instrument, and intimated that if any thing requir'd a farther Explication, he was ready to give it. Nevertheless HEVELIUS could not be prevail'd with to make use of them, whether he thought himself too experienc'd to be inform'd by a young Astronomer, as he reckon'd HOOKE, or whether having made so many Observations with plain Sights, he was unwilling to alter his Method least he might bring their exactness into Question, or whether being by long practice accustom'd to the use of them, and not thoroughly apprehending the use of the other, nor well understanding the difference, as Mr. MOLINEUX has observ'd in his Opticks, is indeed uncertain.

Not long after came out his curious and pompous Book of the first part of his *Machina Cælestis*; and

HOOKE took occasion in his *Cutlerian Lectures*, to read several Discourses upon that Book, and the Instruments therein describ'd, which were printed *Anno* 1674, under the Title of *Animadversions upon Hevelius's Machina Cœlestis*.

In which Treatise vindicating somewhat warmely the benefit of Telescopick Sights and their preference, he chanc'd to let slip some Expressions, which, tho' possibly strictly true, could yet never be digested by HEVELIUS.

Several Years after HEVELIUS publish'd his *Annus Climactericus*, which again reviv'd the Dispute, and caus'd several Learned Men to interest themselves in the Controversy. This, I think, is the true History of the Matter. I shall here subjoin what HOOKE wrote himself in Answer to what some Persons thought fit to write upon this Subject, as I found them drawn up by himself in a Paper or two among his Manuscripts; for the better understanding of which, I shall observe, First, That HEVELIUS having sent his *Annus Climactericus* to the ROYAL SOCIETY, Dr. WALLIS was desir'd to give an account of it, which is printed in the *Philosophical Transactions* No. 175, p. 1162, in which the Dr. having used some Expressions which HOOKE thought reflected too severely upon him; and Mr. MOLINEUX not long after sending a Letter to the same purpose, he wrote his own Vindication almost verbatim, as I have here printed it, at least nothing material is omitted or added.

'There having been lately read in a Meeting of this Honourable *Society* a Letter from Mr. MOLINEUX containing several Reflections that concern'd me,

which, without some satisfactory answer, must needs make me suffer in the Opinion of those who have not truly understood the Matter in Controversy, and the high Esteem I have of the Justice and Judgment of this Illustrious Company, persuades me the rather to make my Defence here.

'The Objections in the Letter were these.

'That if it be true which has been asserted, not only by some celebrated Astronomers, but chiefly by Mr. HOOKE in his *Animadversions*, &c. the Indeavours of HEVELIUS will be frustrated and his vast Charges to no more purpose than TICHO's and all his splendid *apparatus* but meer Lumber; for upon this Question as to plain Sights, the price of his Astronomical Labours of his whole Life depends; but surely this were an Event highly deplorable, not only to the party himself immediately concern'd, but the whole *Respublica Literaria*.

'Secondly, Mention is made of the slightness and smallness of what I had publish'd, which was only a Pamphlet, that asserted, that notwithstanding all this, yet meerly for want of Telescopick Sights and some new kind of invented Divisions on Mr. HEVELIUS's Instruments, I went so far as to doubt whether his Observations could be true, and always the same to two or three Minutes, and that the whole import of it besides this, was nothing but the Description of an Instrument which he never heard was put in practice.

'The Third Objection against me is that, tho' Monsieur HEVELIUS had earnestly requested from me, or any one else that had Telescopick Instruments, to send him some distances of fixt Stars observ'd by them, yet he could never be so happy as to obtain any from me, tho' afterwards he did from some others, *&c.*

'These, and some other Discourses, spread abroad tacitely insinuate that the Publishing those *Animadversions* was a very ill Action, and that the Learned in general have receiv'd a great prejudice thereby, it concerns me therefore to clear my self of this Imputation: For Answer then I say,

'First, If what I have Publish'd in those *Animadversions* be true and certain, then I desire to know whether it were better for

the *Respublica Literaria* to be acquainted with it, or to remain possest with the belief of some Assertions of Monsieur HEVELIUS, which are really Mistakes (not to say worse) tho' possibly till that time, wherein I publish'd them, they were generally believ'd to be Truths, as he has taken a great deal of pains to induce a belief of, in the first part of his *Machina Cælestis*, from Page 293, to Page 300, which I the rather mention, because some Persons have thought and asserted, that I was the first Aggressor in Print, the contrary of which those six Pages evince.

'Secondly, Whether those deplorable Events of lessening the price of Monsieur HEVELIUS's Works, if that were true, when put into the Ballance, will out-weigh the detecting a Mistake, or discovery of a Truth in a matter of so great Moment in Natural Philosophy, as concerns the most considerable parts of Knowledge in the Theory of the Universe, especially of Celestial Bodies; for if Truth be that which is most prevalent with all Philosophical Spirits against any particular Interest, then I hope I shall prove I have not offended in that particular in my publication of those *Animadversions*. And HEVELIUS himself was of the same Mind, when at the sixty first Page of his Preface he writes (speaking of his disparaging some things of TICHO BRAHE) *in hoc negotio semper in cujusuis animo hærere debet. Amicus Plato, Amicus Aristoteles, sed magis tamen amica veritas.* Nor do I find him so shy in proclaiming the Mistakes of TICHO's Observations, when it made for his own Reputation; for in the thirty fourth Page of his Preface he says, that the greatest part of TICHO's Observations differ'd from his own four, five, six, and even ten Min. At the thirty ninth Page he says, That of 780 in TICHO's Catalogue there are but 260 which differ, not less than two Minutes; but all the rest differ 3′, 5′, 10′, 20′, 30′, 40′, 45′, 50′, nay a whole Degree from the truth, and that fifteen differ above a Degree, and some many more, even to eight Degrees in Longitude, and in Latitude to thirteen whole Degrees, sometimes in defect, sometimes in excess, yet for all this HEVELIUS would be thought highly to value TICHO BRAHE, and not to have made any Reflections upon him.

'Nor has the detecting Mistakes even in Persons of as great Fame been look'd upon so ill a thing, but rather a meritorious

Action, as might be instanc'd in Dr. PELL's short Answer in a $\frac{1}{4}$ of a Sheet of Paper to LONGOMONTANUS his Work, which had been the business of thirty Years. Another instance may be of PHOCILIDES upon LANSBERGIUS, the learned *Savilian Astronomick Professor* against BULIALDUS, &c. all which Authors were well esteem'd for their detecting Mistakes, and discovering Truth. And as for any disrespectful or undervaluing Sentiments I had of HEVELIUS or his Performances, I hope what I have printed in my *Animadversions* will prevail with the unprejudiced to believe the contrary; where I say,[1] *That I would not be understood by these Animadversions to undervalue the Works and Performances of a Person so highly meriting the Thanks of the Learned World for his great Expence and vast Pains, in performing a Work so highly useful to Astronomy and Navigation, that I did not in the least doubt but that it would be a Work of perpetual Esteem, and much preferrable to any thing of the like kind yet done in the World; and that he had gone as far as was possible for humane Industry to go with Instruments of that kind, which were as compleat and exact as Instruments with plain Sights could be made; and that he had calculated with all imaginable care and skill, and deliver'd them with the like Candor and Integrity: But yet that it was my Opinion, that this ought not to discourage others from making use of Telescope-sights, and to make better Observations with Instruments by that means more exact.*

'This I hope may Apologize for my writing those *Animadversions*.

'But in the next place I must make some defence for what is said in them. This Gentleman says I went so far as to doubt whether HEVELIUS's Observations could be made true and always the same to two or three Minutes, I wish the place had been quoted where I said so,[2] since I only said that I believ'd it impossible for any one to distinguish with common Sights any distance in the Heavens to less than half a Minute, and very few to a Minute, and I am apt to believe there may be some instances even in HEVELIUS's Catalogue that will verify this Assertion.

'And for any other Assertion, which is *really mine* in that Treatise, I do not doubt of satisfying any unprejudiced Person by experiment, if desir'd, which I say, is *really my Assertion*; for

[1] Pp. 43 & 44. [2] *Animadversions*, Pag. 7.

by mistake or otherwise, some things have been fathered upon me I never said, *viz.* that I should assert, *That an Instrument of a span Radius might be made, that should perform Observations sixty times more accurate than could be done with his best Instruments:* Which Assertion is none of mine, and whoever have spread these Falsities, might have found better Employment. I say indeed, that a very small Instrument, curiously made, exactly divided and instructed with Telescope-Sights will perform much better in all Observations (except of the Sun) than the largest Instrument without such Sights, for the reason before alledged from the defect in our Eyes which cannot distinguish an Angle less than half a Minute, nor is this a defect in my own Eyes only (as HEVELIUS somewhere seems to hint) for the Experiment may easily be try'd with the best Eyes.

'Nor is it any disparagement to HEVELIUS's Observations to compare them with TICHO BRAHE's, tho' I should have suppos'd them but of equal value, since the mere repeating of his Observations would be of great use in Astronomy, these being almost one hundred Years after his; for we must by such comparisons judge of many considerable inquiries concerning Celestial Bodies, which cannot by other means be so well detected, for which I refer to the seventy-sixth Page of my *Animadversions*, viz. to know whether those Celestial Bodies which are suppos'd so fixt, do not vary their Positions to each other, and also their Magnitudes, which I had good grounds to believe.

'As to the Objection that my Pamphlet contain'd *little besides the Description of an Instrument never put in practice.* I conceive there may be several Mistakes; for I am of Opinion, upon perusal there will be somewhat else in that Treatise worth consideration. Next that there has been Instruments made, perfected and used after that way, by Sir JONAS MORE, by Mr. GREGORY in *Scotland*, by Mr. HALLEY, and many others, and I believe very few Astronomical Instruments since have been made with plain Sights; and if the multitude of Authorities were necessary, I could produce AUZOUT, PICART, MARIOT, ROMER, DE LA HIRE, MONTANARI, GOTIGNIES, and others, not to name those of our own Nation.

'As to my not returning the Observations of certain distances

of Stars, which Hevelius desir'd, 'tis sufficiently known what inconveniences we lay under in this place after the Fire of *London*, and had I found conveniences, yet the unkind Reception those things found, which I sent him, was enough to deter me from such a Compliance; tho' he was sensible how I had often been ready to gratify his Curiosity in many other particulars. But when his *Machina Cælestis* was publish'd, I was oblig'd to write those *Animadversions*, in which I hope all unprejudic'd Readers will justify my procedure, at least I am ready to prove any thing I have therein asserted.'

I have been the larger in the Account of this Controversy that the intelligent Reader may make the better judgment thereof, it being the most considerable he ever had with any Person, and shall wave the giving my Opinion of it.

Further Inventions.

In 1674, he shew'd an Engine or Instrument to perform any Arithmetical Operation, but the more particular account of this and other Instruments not describ'd in this Volume [*Posthumous Works*], I shall reserve for another opportunity.

About the latter end of the same year the Royal Society kept their Weekly Meeting at *Gresham College* again, and on [December the 19 the Gresham committee, in order to incourage Mr. Hooke in his curious and useful inquiries, were pleased to allow him forty pounds to erect a turret over part of his lodgings, for trying his instruments, and making observations in the heavens.] On the fifteenth of *Jan.* following he shew'd a way to determine how small an Angle the unassisted Eye is able to discern, by which it was found, that none of the Persons Eyes present could observe a much less Angle than of a Minute;

for a more ample account of which the Reader is referr'd to the eighth Page of his *Animadversions*.

From this time many Magnetical Experiments were made by him, and on the nineteenth of *March* he propos'd a Theory of the variation, the substance of which was this, 'That the Magnet hath its peculiar Poles distant ten Degrees from the Poles of the Earth, about which they move so as to make a Revolution in three hundred and seventy Years, whence the variation hath altered of late about ten or eleven Minutes every Year, and will probably continue so to do for some time, till it begins to grow slower and slower, and will at length be Stationary and Retrograde, and in probability may return; but whether it will be so or not, Time must shew.' At the same time he propos'd the making of a very easy and nice Instrument to observe the variation of the variations of the Needle in different parts of the World.

What this Instrument was is not easy now to be determin'd, but the Reader will find the Figure of an Instrument something to this purpose [in the *Posthumous Works*, Pl. ix, fig. 1.]

On the 4th of *Feb.* 1674/5, several Observations and Discourses having been made about the Structure of the Muscles of Animals, Mr. Hooke said, 'That his Observation was, that the fleshy part of a Muscle consisted of an infinite number of exceeding small round Pipes, extended between the two tendons of the Muscles, and seem'd to end in them. Which Tendons, in the Muscles of Beef boyl'd would be easily stript off from those Pipes, and so leave the round ends of those Pipes very distinct and visible: He said that the reason of the moving of a Muscle

might be from the filling or emptying of those Pipes, whose sides seem'd to be flexible like those of a Gut. He intimated also, that he knew a way of making succedaneous Muscles for a Man to supply the defect of his Muscles for flying, and give one Man the strength of ten or twenty, if required.'

[On the 25 of the same month it was ordered, that he should, with the first conveniency, remove the museum and library belonging to the Royal Society from Arundel house into the west or white gallery in Gresham college, and perfect the catalogues of both; but it was the winter following before the gallery could be prepared for their reception, and then the rarities were conveyed thither; tho the books remained long afterwards at Arundel house.]

'*March* the 18th 1674/5, he made an Experiment of a new property of Light, having before read some Discourses upon that Subject.'[1]

Dispute with Oldenburg.

[Soon after this he was ingaged in a dispute with Mr. Oldenburg, who at that time published the *Philosophical Transactions,* which began on the following occasion. It has been observed already, that Mr. Hooke soon after the restoration shewed the movement of a watch, regulated by a spiral spring applied to the arbor of the balance, and designed for discovering the longitude, to some of his freinds, thro whose interest in the year 1663 he might have had a patent for the invention; but not liking the conditions, the matter was thereupon laid aside.

[1] *Posthumous Works,* p. 186.

The year following he read several of his Cutlerian lectures upon that subject, in the reading hall at Gresham college, and caused several of the said watches to be made. Some account likewise of this invention was afterwards given in the *History of the Royal Society* (tho not so full as Mr. Hooke could have wished) where among other inventions are recounted "several new kinds of pendulum watches for the pocket, wherein the motion is regulated by springs, *etc.*" Thus continued this affair, till Mr. Huygens sent a letter to the royal society, dated the 30 of January 1674, acquainting them with an invention of his of very exact pocket watches, the nature and contrivance of which he imparted to them in an anagram, which in a subsequent letter of February the 20 he explained by a full description; for which the society returned him thanks, and at the same time intimated to him, that Mr. Hooke had some years before invented a watch of the like contrivance. Not long after there came over in the *Journal des Scavans* a printed description of Mr. Huygens's invention, with a delineation of its figure; an extract of which *Journal* was printed March the 12, 1674, in the *Philosophical Transactions*. This gave offense to Mr. Hooke; who in a *Postscript* to his *Description of Helioscopes*, printed in 1675, complains of Mr. Oldenburg, the publisher of the extract, for omiting to take notice, "that this invention was first found out by an English man, and long since published to the world; and calls it *unhandsome proceedings*." And at the same time he sais, that as to the models he had yet produced, he was unwilling to add any of the better applications of the spring to them,

waiting for an opportunity more to his advantage. But to this Mr. Oldenburg in the *Transaction* for October the same year replies, that Mr. Hooke both saw and copied the figure of Mr. Huygens's watch, before the extract of the *Journal* was made. And as he knew both would be published in one of the *Transactions*, had he given to the editor of them the least intimation, that he desired notice might be taken at the same time of his invention of the like kind, it would have certainly been done, as it had been before on other occasions. But seeming to resent it, that he should be charged with *unhandsome proceedings* on this account, in return sais; "that tho Mr. Hooke had some years before caused some watches to be made of this kind, yet without publishing to the world a description of them *in print*; and that none of those watches *succeeded*." In answer to this Mr. Hooke in a *Postscript* to his *Lampas*, published in 1676, blames him for affirming, "what he could not know with regard to the *success* of his watches; whom (as he sais) he had not acquainted with his inventions, since he looked on him as one, *who made a trade of intelligence*." And as to his not having *himself* published them to the world *in print*, he sais; "they were publickly read of in Sir John Cutler's lectures, shewn to thousands both English and foreiners, writ of to several persons absent, and published *in print* in the *History of the royal society*." Whether Mr. Hooke's watches were *unsuccessful*, or not, Mr. Waller sais, "he could not learn; but was inclin'd to think, that expression of Mr. Oldenburg proceeded from passion, the invention and principle of Hooke's and Huygens's being both the

very same, as are now us'd." [1] Mr. Oldenburg took no further notice of this rejoinder of Mr. Hooke, than to publish the following *Advertisement* at the end of the *Transaction* for the months of August and September in 1676:

"The publisher of this tract intends to take another opportunity of justifying himself against the aspersions and calumnies of an immoral *Postscript*, put to a book, called *Lampas*, publisht by Robert Hooke. Till which time 'tis hoped, the candid reader will suspend his judgment."

And to the next *Transaction* was subjoined the following *Declaration* of the council of the royal society.

> "A Declaration of the Council of the Royal Society, passed November 20, 1676, relating to some passages in a late book of Mr. Hooke, entituled *Lampas*, etc.

"Whereas the publisher of the *Philosophical Transactions* hath made complaint to the council of the royal society of some passages in a late book of Mr. Hooke, entituled *Lampas, etc.* and printed by the printer of the said society, reflecting on the integrity and faithfulness of the said publisher, in his *management of the intelligence* of the said society: This council hath thought fit to declare in the behalf of the publisher aforesaid, that they knew nothing of the publication of the said book; and further, that the said publisher hath carried himself faithfully and honestly in the *management of the intelligence* of the royal society, and given no just cause of such reflections."

Thus ended this controversy, which might have

[1] Cf. p. 15.

been sooner over, had some warm expressions been forborn on either side.]

[Mr. Hooke, besides his office of curator to the royal society, had likewise the care both of their repository and books, till the year 1676; when upon the 6 of April the curiosities in the repository were ordered to be delivered to Mr. Richard Shortgrave, operator to the society, who was succeeded in both those places November the 2 following by Mr. Henry Hunt.]

Death of Oldenburg.

Mr. OLDENBURGH, the then Secretary, dying in the time of the Societies Recess, 1677, Mr. HOOKE was desir'd to take his place, and take the Minutes of what considerable Matters past, which he did on the twenty fifth of *October* 1677, and the same day produc'd his Water-poise and shew'd the nicety thereof.

There were afterwards some other Hydrostatical Instruments produc'd, as likewise many Improvements of the double and single Microscopes, with the use of small glass Canes and other Contrivances, by which he verify'd Monsieur LEUENHOOK'S Observations; these, with several others, I omit, they not being so intelligible without Schemes.

[The disappearance of Mr. OLDENBURG from the scene entirely changed Hooke's relations with the Society; and as Ward narrates:

The *Philosophical Transactions* were first published by Mr. Oldenburg, who began at the 6 of March 1664, and continued them to the end of June 1677, without any intermission, except for about four months, from July the 3 to November the 6 in the year 1665,

when the society was dispersed on account of the sickness. Upon the 30 of November 1677 Dr. Nehemiah Grew, being chosen secretary, resumed the publication of them with the month of January next insuing, so that none were printed for the six preceeding months. He carried them on to the end of February 1678; and in the same year Mr. Hooke published his lectures called *Cometa* and *Microscopium,* as likewise those *De potentia restitutiva,* in which he stiles himself *Secretary of the Royal Society.* After this the *Transactions* were again omited from February 1678 to January 1682, during which interval Mr. Hooke published his seven *Philosophical collections.* Upon the 30 of November 1682 Dr. Robert Plot being made secretary in the room of Mr. Hooke, the publication of the *Transactions* was again revived, begining with the month of January next insuing; in the preface to which it is observed, that they had been discontinued for the four last years. From that time the publishing of them was regularly continued to the end of December 1687, when the unsettled state of public affairs put a fresh stop to them for three years. But then the work was again renewed, begining with January 1690, and they have since been constantly printed by the succeeding secretaries of the society, as formerly; except that there is a small chasm of the months November and December in the year 1691, and another from May to October in 1695; and that those for the year 1713 are printed without any distinction of months. But I return to Mr. Hooke (who from October 25, 1677, to 1682 was one of the two Secretaries of the Society).]

From that time he officiated in that Place, as well

as his Curatorship, shewing several Experiments and Instruments in order to explain the Gravitation and Alterations in the Air by Vapours, *&c.* Contriving an Air-poise to shew the different specifick Gravity of the Air by a large thin ball of Glass counter-poised.

In *Feb.* 1677/8, upon an account of Monsieur GALLET'S Observation of the Oval Figure of *Mercury* in the Sun, he gave several reasons for the prolated Oval Figure of the Planets,[1] with a Demonstration thereof, and said, 'That all Fluids on the Surface would run into that Shape, and that 'twas not improbable but that the Water here about the Earth might do so by the influence of the diurnal Motion of the Earth, which compounded with that of the Moon, he conceiv'd was the cause of the Tides.'

From this time he made Microscopal Observations on *Animalcules* in Pepper-water, and other Seeds steeped in Water, confirming Monsieur LEUENHOOK'S Assertions, and propos'd some Improvements of Microscopes.

Some proposals were made by him of Instruments more accurate than those formerly invented for sounding the Seas depth, bringing up Water, or other Substances from the bottom, or any assigned depth which were some Years after more perfected.

Apr. 25, 1678, he shew'd an Experiment farther to explain the action of a Muscle, 'which was by a Chain of small Bladders fastened together, so as by blowing into one Pipe, the whole might be successively fill'd, and by that means contracted, supposing the Fibres of the Muscles which seem'd like a Necklace of Pearl in the Microscope, might be fill'd with

[1] *Posthumous Works*, p. 355.

a very agill Matter, which he thought most likely to be Air, which being included in so thin Skins, was easily wrought upon by Heat, Cold, or the acting Properties of the Liquors that pass between them, and so perform the lengthening and contracting of the Muscles.'

Aug. 1678, he read several Discourses, and shew'd Experiments in order to confirm his Theory of Springs and springy Bodies, which are publish'd in his Treatise *de Potentia restitutiva* the same Year, the sum of which Hypothesis is comprized in a Cypher at the end of his Description of Helioscopes, being the third of a Decimate of Inventions which he there mentions he was Master of, some of which he discover'd himself, affirming he had a Century of the like useful Inventions: Others of them I have had the luck to find out, which I shall take this opportunity of mentioning. I shall first transcribe what he says of them, and then add the deciphering of them.

The second Invention, which is the first Cypher, is thus worded.

'The true Mathematical and Mechanical Form of all manner of Arches for building with the true butment necessary to each of them, a Problem which no Architectonick Writer hath ever yet attempted, much less perform'd. ab, ccc, dd, eeeee, f, gg, iiiiiii, ll, mmmm, nnnnn, oo, p, rr, sss, tttttt, uuuuuuuu, x, which deciphered is these words, *Vt pendet continuum flexile, sic stabit contiguum rigidum inversum*, which is the *Linea Catenaria*.'

The third is his Theory of Springiness in these Letters, ce, iii, no, sss, tt, uu, which is *Vt Tensio sic vis*; this is the principle of his Theory of Springs.

'The ninth, which is the next Cypher, is concerning a new sort of Philosophical Scales of great use in Experimental Philosophy, cde, ii, nn, oo, p, sss, tt, uu—*Vt Pondus sic Tensio*.'

The last is mention'd as a very extraordinary invention in Mechanicks above the Chimeras of perpetual motions for several uses, aa, æ, b, cc, dd, eeeeee, g, iii, l, mmm, nn, oo, pp, q, rrrr, s, ttt, uuuuu. *Pondere premit aer vacuum quod ab igne relictum est.* This is one of the Principles upon which Mr. SAVERY's late invented Engine for raising Water is founded.[1]

On the 29th of *Aug.* 1678, his Grace the Duke of *Norfolk* having given the *Arundelian* Library to the ROYAL SOCIETY, Mr. HOOKE was order'd to be Assistant in making a Catalogue thereof, and removing it to *Gresham College*, [which was accordingly done, and the books were placed in the south or long gallery, which was then prepared to receive them. And February the 27 next insuing the office of librarian to the society, which was then ordered to be appointed, being offered to him, he thought fit to decline it, and Mr. William Perry was elected. Mr. Hooke having thus quited himself of the charge both of the repository and library, was more at leisure to attend to his experiments and lectures. And having been hitherto prevented from perfecting the two catalogues of the museum and library, as had been directed by the council of the society, both were done by other hands, as will be shewn afterwards.]

In the beginning of the Year 1679, and afterwards, several Experiments were repeated to examine the

[1] See *Lexicon Technicum* under Engine.

use of the Air in Respiration by including Animals in common rarify'd and condensed Air, as likewise concerning the necessity of the Air to maintain Fire, to illustrate his Theory of Fire farther, *viz.* 'That Air is a *Menstruum* that dissolves all Sulphureous Bodies by burning, and that without Air no such dissolution will follow, tho' the heat apply'd be never so great, which was try'd particularly by a Charcoal enclosed in an Iron Case with a Screw-stopper, which tho' violently heated yet the Cole was not burnt nor wasted when taken out.'

Some Experiments were made to explain the different Gravitation of the Air, and to shew that Vapours press only according to their own Gravity, and not according to the space they take up in the Atmosphere.

Some Contrivances were shewn by him to be added to the Weather-Clock, as a Hygroscope, a contrivance to measure the quantity of Rain, Snow, or Hail fallen in a certain time; which Engine was soon after perfected in all its parts, and set up in the Repository.

In *July* 1679, he read a Discourse concerning a way to help short Sighted Persons, which he call'd *Myopibus Juvamen*; this is printed in his third Collection, p. 59. 'At the same time he gave his Thoughts of the reason of the different apparent Magnitude of the Sun and Moon in the Meridian and near the Horizon, which he suppos'd to be a deception of the Eye as judging them when near the Horizon, to be farther off than when nearer the Zenith, for that he said the Diameters measur'd were really the same in both places, or rather some-

thing less in the Horizon than in the Zenith, being remov'd a Semidiameter of the Earth farther off.'

Experiments were made by him of the mixtures of Metals, particularly of Copper and Tin, in which there was observ'd a real Penetration, the *Compositum* being specifically heavier than either of the Metals before mixture; for whereas Copper is to Water as $8\frac{1}{2}$ to 1, and Tin to Water as $7\frac{17}{30}$ to 1, the compositum was to Water as $8\frac{3}{4}$ to 1.

'In *December*, the same Year, an Experiment being suggested to try whether the Earth mov'd with a diurnal motion or not, by the fall of a Body from a considerable height, alledging it would fall to the East of true Perpendicular: Mr. Hooke read a Discourse upon that Subject, wherein he explain'd what the Line describ'd by a falling Body must be, suppos'd to be mov'd circularly by the diurnal motion of the Earth, and perpendicularly by the power of Gravity, and shew'd it would not be a Spiral Line, but an Excentrical-Elliptoeid, supposing no resistance in the *medium*, but supposing a Resistance, it would be an Excentric-Ellipti-Spiral, which after many Revolutions, would rest in the Center at last; that the fall of the Body would not be directly East, but to the South-East, and more to the South than the East. This was try'd, in which the Ball was still found to fall to the South-East.'

The remainder of this Year was spent in making Experiments of the mixture of several Metals, among the rest Mr. Hooke took notice in the mixture of Copper and Tin of several particulars, as First, 'That the colour of the Copper was quite destroy'd, it appearing much of the colour of Iron Polish'd.

Secondly, That the Composition, tho' made of two very malleable Metals, was yet very brittle and friable. Thirdly, That it bore a pretty good Polish and Reflection. Fourthly, That tho' Copper is exceeding hard to be melted, yet the mixture melted very easily. Fifthly, That viewing the Polish'd Surface with a Microscope, he found it very full of very small holes or blebs in the Metal.'

In *April* 1680, he produc'd a new invented Level.

In *May* he read a Paper of Observations upon an unusual sort of Hail-stones that fell on the 18th, the sum of which was to this purpose. About ten a Clock in the Morning it grew very dark and Thundered much, and near to the S.E. when soon after the Hail fell from the size of Pistol-Bullets to the bigness of Pullets Eggs, the smaller were white like Chalk, and pretty round, the larger Conical or Oval, upon breaking them they were found to be made of several Orbs, encompassing one another; several had a white Center or Nucleus in the middle, which in others was more toward one side; they that exceeded in bigness were made by an additional accretion of transparent Icecles, radiating from the white Ball in the middle; some of these stood in distinct transparent Rays, in others the Interstices were fill'd up between the Rays with a white opaque Concretion: The lower part of these Stones were more flat and like a Turnip, the radiations appearing more towards the upper side; the sides and top were more rough, and the ends of the Stiriæ were prominent. Before they fell a great noise was heard in the Sky: From the manner of their Figure Mr. HOOKE conceiv'd their accretion was made by a congelation of Water as they fell;

that the Globe in the middle about the bigness of a Pea, was the first drop that concreted into Hail, the Coats being added to it as it past through the watry Clouds, of which some were white, some pellucid, according to the different coldness of the Regions they past through.

July 8th 1680, upon a Debate concerning the Experiment of my Lord BACON's of the internal motion of Bodies, Mr. HOOKE related, 'That he had observ'd that the motion of the Glass, fill'd with Water, was observ'd to be vibrative, perpendicular to the Surface of the Glass, and that the Circular Figure chang'd into an Oval one way, and that the Reciprocation presently changed it into an Oval the other way, which he discover'd by the motion of the Undulation or rising of the Water in the Glass, which was observ'd to be in four places of the Surface in a square posture, the same Glass being struck on the edge with a Viol-bow, this square Undulation was very plain, and there was also discover'd another Undulation, by which the Water was observ'd to rise in six places like an Hexagon, and upon farther trials also in eight places like an Octagon; each of these gave their particular and distinct Sounds or Notes, the 4 and 8 were Octaves, and the 6 and 4 were Fifths, *&c.*'

In *November* 1680, he read some Observations he had made of a *Comet* then appearing, which, with other Observations and Discourses of other Comets are publish'd under that Title.[1]

And about this time Mr. HOOKE shew'd a Contrivance by a *Statera* to examine the attractive

[1] *Posthumous Works*, p. 149.

power of the Magnet at several distances, and made many Experiments therewith.

In *April* 1681, and afterwards, he read his Lectures of *Light* and *Luminous* Bodies, which have been collected together.[1]

In *July* the same Year he shew'd a way of making *Musical and other Sounds*, by the striking of the Teeth of several Brass Wheels, proportionally cut as to their numbers, and turned very fast round, in which it was observable, that the equal or proportional stroaks of the Teeth, that is, 2 to 1, 4 to 3, *&c.* made the Musical Notes, but the unequal stroaks of the Teeth more answer'd the sound of the Voice in speaking.

November following he mention'd a new Sea-Quadrant for making Observations more accurate than could be done by any Instrument yet known; this is what the Reader will find towards the end of this Volume:[2] At the same time he first mention'd his new Compasses for describing all sorts of Spirals, as likewise of the Rumb-lines, which Instrument I also have indeavour'd to retrieve from being lost.

Soon after this he shew'd and demonstrated a very expeditious way of drawing the Rumb-lines exactly true upon a Globe, by an Instrument grounded upon the same Principle with the other. He shew'd also a very easy way of finding all the possible *foci* of Rays refracted by a *Plano-Spherical Lens*, whereof the Convex side was turn'd toward the *focus*, as also the quantity of Rays that would pass thro' such a Glass, whose Convexity was of the full bigness of a Hemisphere.

[1] loc. cit., p. 71.

[2] loc. cit., pp. 557–8.

'In *Jan.* 1681/2, he shew'd an Instrument to describe all sorts of *Helixes* upon a Cone, by which he affirm'd to be able to divide any given length, tho' very short, into almost any assignable number of given parts, as suppose an Inch into 100000 equal parts; this he conceiv'd very useful for perfecting Astronomical and Geographical Instruments. And at the next Meeting he produc'd another Instrument, by which he describ'd a certain Curve Line, which may be call'd an *Inverted Parabola*, or *Parabolical-Hyperbola*, having these Proprieties, that it is infinite both ways, and hath two *Asymptotes* as an *Hyperbola*, &c. A third Instrument was also shew'd for exactly describing the *Spiral* of ARCHIMEDES by a new Propriety thereof, and that as easily and truly as a Circle, whereby not only any given Arch might be divided into any number of equal parts, but a strait Line given equal to the Circumference of a Circle.

'*March* the first, he shew'd a way, by the same Instrument, of describing all varieties of Ellipses.'

In the same Year he read the remainder of his Discourses of *Light*, which are printed, and particularly that Lecture explicating the *Memory*, and how we come by the notion of Time.

From this time, or rather something before, he began to be more reserv'd than he had been formerly, so that altho' he often made Experiments, and shew'd new Instruments and Inventions, and read his *Cutlerian* Lectures, yet he seldom left any full Account of them to be enter'd, designing, as he said, to fit them himself for the Press, and then make them publick, which he never perform'd. This is the reason

that I am oblig'd to be the shorter in the remaining part of his Life; and shall only touch upon some few of his Performances, since the bare nameing of them, or mentioning their Titles, will but create an uneasy Curiosity in the Reader without any satisfaction.

Several of these Lectures and Discourses I have endeavour'd to preserve from being lost, by Publishing them in this Book, and some Instruments are there describ'd.

In the beginning of the Year 1687, his Brother's Daughter, Mrs. GRACE HOOKE dy'd, who had liv'd with him several Years, the concern for whose Death he hardly ever wore off, being observ'd from that time to grow less active, more Melancholly and Cynical.

On the fifth of *May* he read a Lecture of the unequal *diurnal* motion of the Earth, which the reader may find in his Posthumous Works.

In *July* he shew'd an Experiment of the communication of Motion by a Packthread extended a very considerable length, and, after running over a Pulley, brought back to the place, near to which the other end was fastened, and it was found that any addition of Weight or Motion given to the one end, would be immediately sensible at the other end of the String, tho' it must pass in going and returning so great a length; there were other ways shewn of communicating motion, as by a long Cane suspended by Strings, or by Wires distended a great length; in which it was observable, that the sound was propagated instantaneously, even as quick as the motion of Light, the sound convey'd by the Air coming a considerable time after that by the Wire.

A great part of the next Year he was very weak and ill, being often troubl'd with Head-achs, Giddiness and Fainting, and with a general decay all over, which hinder'd his Philosophical Studies, yet still he read some Lectures whenever he was able. At the same time a Chancery-Suit, which he was forc'd to have with Sir JOHN CUTLER for his yearly Salary, made him very uneasy, the trouble of which increas'd his Illness.

But on the 20th of *June* he read a farther Description concerning several ways of making a portable *Sea-Barometer*, with the great uses thereof in foretelling changes of the Weather and Storms.

From this time, for some Years, I find but little done by him, except his reading the Lectures founded by Sir JOHN CUTLER, several of which are printed,[1] to which the curious are referr'd: Of these he read in *Dec.* 1691, several relating to improvements of Sounding Instruments which he call'd *Nuntii inanimati ad fundum Abyssi emissarii*. Having receiv'd a warrant from Dr. TILLOTSON the Arch-bishop of *Canterbury*, for a degree of *Dr. of Physick*, he went on the 7th of *Dec.* the same Year, and took the Oaths before Sir CHARLES HEDGES in *Doctors Commons*.

About this time he was employ'd about the contriving and surveying the Hospital standing near *Hoxton*, given by the Will of Alderman ASK, a Building that few will judge any disreputation to the Contriver, for the due proportion of its Parts, and Beauty of the whole. I have heard indeed that Dr. HOOKE has been blam'd for exceeding the Sum at first propos'd to be expended thereon; and once

[1] *Posthumous Works.*

discoursing with him upon that Subject, he own'd to me that it had far exceeded the first Estimate he had given in of the Charges, but not by this Fault or Mistake, but partly by new additions and alterations of the first Design, and chiefly by his not procuring and agreeing with the Workmen himself, which if he had done, as he said, he would have ingag'd it should have come to little or no more than his first propos'd Sum.[1] He also propos'd that there might be instituted in that place, a *Mathematical-School* for Boys to be instructed in the Principles of *Astronomy* and *Navigation*, which at first was well approv'd of by the Persons concern'd in the Management of that Affair.

On *Thursday* the 8th of *Sep*. 1692, he sets down an Earthquake to be observ'd by himself exactly 55 Min. past one a Clock p.m. he notes that there was no Wind but Rain all Day. It was remarkable that this Earthquake was felt at the same time not only in most parts of *England*, but also in several parts of *Germany*.

This Year he read a curious Discourse describing the Tower of *Babel* or *Belus*. The Year following he read several Lectures about Earthquakes, and an Explication of OVID's *Metamorphosis*, of which it is needless to mention the Contents, or the Times, the Dates of most of them being affixt to them in the [*Posthumous Works*, where they begin at page 377].

On the 18th of *July* 1696, being his Birth Day, his Chancery-Suit for Sir JOHN CUTLER's Salary,

1 HOOKE's other important buildings are enumerated on p. 31, and for his survey of the Monument built by Sir Christopher Wren see p. 527.

was determin'd for him, to his great satisfaction, which had made him very uneasy for several Years. In his Diary he shews his sense of it in these Terms DOMSHLGISS:A. which I read thus *Deo Opt. Max. summus Honor, Laus, Gloria in secula seculorum, Amen. I was Born on this Day of* July 1635, *and* GOD *has given me a new Birth, may I never forget his Mercies to me; whilst he gives me Breath, may I praise him.*

March the 5th 1697/8, he read a Lecture about the prolated Spheroidical Figure of the Sun, and other *Phænomena* thereof, of the *Maculæ* and *Faculæ*, &c. of making a Helioscope by four reflex Planes in a twenty four Foot Tube, or a Telescope for Planets and fix'd Stars, by two Reflexions in a Tube of forty Foot with Monsieur HUYGENS 120 Foot Glass, which was well lik'd of.

June 27, 1698, he read a Lecture upon HUYGENS' *Cosmotheoros*, and shew'd a Module of *Saturn* and his Ring.

Declining Years.

Thus I have mention'd some of his Performances, in the latter of which I have been the more succinct, having exceeded the bounds I at first intended in the Accounts of the former. It must be confessed that the later part of his Life was nothing near so fruitful of Inventions as the former; tho' it is certain he had a design to repeat the most part of his Experiments, and finish the Accounts, Observations and Deductions from them, and had an Order for the Societies bearing the Charge thereof, in *June* 1696, when he propos'd likewise to perfect the Description of all

the Instruments he had at any time contriv'd; but by reason of his increasing Weakness and a general Decay, he was absolutely unable to perform it, had he desir'd it never so much.

He had for several Years been often taken with a giddiness in his Head, and sometimes great Pain, little Appetite, and great faintness, that he was soon very much tir'd with walking, or any Exercise. About *July* 1697, he began to complain of the swelling and soreness of his Legs, and was much over-run with the Scurvy, and about the same time being taken with a giddiness he fell down Stairs and cut his Head, bruis'd his Shoulder, and hurt his Ribbs, of which he complain'd often to the last. About *September* he thought himself (as indeed all others did that saw him) that he could not last out a Month. About which time his Legs swell'd more and more, and not long after broke, and for want of due care Mortify'd a little before his Death. From this time he grew blinder and blinder, that at last he could neither see to Read nor Write. Some of the last he wrote, I believe was on the 17th of *Dec.* 1702, when he sets down a Memorandum about an Instrument to take the Horizontal Diameter of the Sun to the tenth of a second Minute, but discovers not the way.

Thus he liv'd a dying Life for a considerable time, being more than a Year very infirm, and such as might be call'd Bed-rid for the greatest part, tho' indeed he seldom all the time went to Bed but kept in his Cloaths, and when over tir'd, lay down upon his Bed in them, which doubtless brought several Inconveniences upon him, so that at last his Dis-

tempers of shortness of Breath, Swelling, partly of his Body, but mostly of his Legs, increasing, and at last Mortifying, as was observ'd after his Death by their looking very black, being emaciated to the utmost, his Strength wholly worn out, he dy'd on the third of *March* 1702/3, being 67 Years, 7 Months, and 13 Days Old.

His Corps was decently and handsomely interr'd in the Church of St. *Hellen* in *London,* all the Members of the Royal Society then in Town attending his Body to the Grave, paying the Respect due to his extraordinary Merit.

His Character.

As to his Person he was but despicable, being very crooked, tho' I have heard from himself, and others, that he was strait till about 16 Years of Age when he first grew awry, by frequent practicing, turning with a Turn-Lath, and the like incurvating Exercises, being but of a thin weak habit of Body, which increas'd as he grew older, so as to be very remarkable at last: This made him but low of Stature, tho' by his Limbs he shou'd have been moderately tall. He was always very pale and lean, and laterly nothing but Skin and Bone, with a meagre Aspect, his Eyes grey and full, with a sharp ingenious Look whilst younger; his Nose but thin, of a moderate height and length; his Mouth meanly wide, and upper Lip thin; his Chin sharp, and Forehead large; his Head of a middle size. He wore his own Hair of a dark Brown colour, very long and hanging neglected over his Face uncut and lank, which about three Year before his Death he cut off,

and wore a Periwig. He went stooping and very fast (till his weakness a few Years before his Death hindred him) having but a light Body to carry, and a great deal of Spirits and Activity, especially in his Youth.

He was of an active, restless, indefatigable Genius even almost to the last, and always slept little to his Death, seldom going to Sleep till two, three, or four a Clock in the Morning, and seldomer to Bed, often continuing his Studies all Night, and taking a short Nap in the Day. His Temper was Melancholy, Mistrustful and Jealous, which more increas'd upon him with his Years. He was in the beginning of his being made known to the Learned, very communicative of his Philosophical Discoveries and Inventions, till some Accidents made him to a Crime close and reserv'd. He laid the cause upon some Persons, challenging his Discoveries for their own, taking occasion from his Hints to perfect what he had not; which made him say he would suggest nothing till he had time to perfect it himself, which has been the Reason that many things are lost, which he affirm'd he knew.[1] He had a piercing Judgment into the Dispositions of others, and would sometimes give shrewd Guesses and smart Characters.

From his Youth he had been us'd to a Collegiate, or rather Monastick Life, which might be some reason of his continuing to live so like an Hermit or Cynick too penuriously, when his Circumstances, as to

[1] 'But he seems, in some instances at least to have carried these pretensions too far; particularly in his claim to several things in the theory of Sir ISAAC NEWTON'S *Philosophiae naturalis principia mathematica*, which that illustrious writer has shewn to have been his own.' WARD, *Lives*, p. 188.

Estate, were very considerable, scarcely affording himself Necessaries.

I indeed, as well as others, have heard him declare sometimes that he had a great Project in his Head as to the disposal of the most part of his Estate for the advancement of Natural Knowledge, and to promote the Ends and Designs for which the ROYAL SOCIETY was instituted: To build an handsome Fabrick for the *Societies* use, with a Library, Repositary, Laboratory, and other Conveniencies for making Experiments, and to found and endow a perpetual *Physico-Mechanick Lecture* of the Nature of what himself read. But tho' he was often solicited by his Friends to put his Designs down in Writing, and make his Will as to the disposal of his Estate to his own liking in the time of his Health; and after when himself, and all thought, his End drew near, yet he could never be prevail'd with to perfect it, still procrastinating it, till at last this great Design prov'd an airy Phantom and vanish'd into nothing. Thus he dy'd at last without any Will and Testament that could be found. It is indeed but a melancholy Reflexion, that while so many rich and great Men leave considerable Sums for founding Hospitals, and the like pious Uses, few since Sir THOMAS GRESHAM should do any thing of this kind for the promoting of Learning, which no doubt would be as much for the Good of the Nation, and Glory of God, as the other of relieving the Poor.

He always exprest a great Veneration for the eternal and immense Cause of all Beings, as may be seen in very many Passages in his Writings, and seldom receiv'd any remarkable Benefit from God

without thankfully acknowledging the Mercy; never made any considerable discovery in Nature, invented any useful Contrivance, or found out any difficult Problem, without setting down his Acknowledgement to the Omnipotent Providence, as many places in his Diary testify, frequently in these or the like words, abbreviated thus, D O M G M, and was a frequent studier of the Holy Scripture in the Originals: If he was particular in some Matters, let us leave him to the searcher of Hearts.

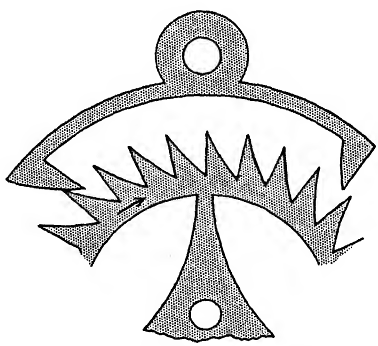
To conclude, all his Errors and Blemishes were more than made amends for, by the Greatness and Extent of his natural and acquired Parts, and more than common, if not wonderful Sagacity, in diving into the most hidden Secrets of Nature, and in contriving proper Methods of forcing her to confess the Truth, by driving and pursuing the PROTEUS thro' all her Changes, to her last and utmost Recesses; so that what OVID said of PYTHAGORAS may not unfitly be apply'd to him.

Mente Deos adiit, & quæ Natura negavit
Visibus humanis, oculis ea Pectoris hausit.
Metamorph. Lib. 15, 63.

There needs no other Proof for this than the great number of Experiments he made, with the Contrivances for them, amounting to some hundreds; his new and useful Instruments and Inventions, which were numerous, his admirable Facility and Clearness, in explaining the Phænomena of Nature, and demonstrating his Assertions; his happy Talent in adapting Theories to the Phænomena observ'd, and contriving easy and plain, not pompous and

amusing Experiments to back and prove those Theories; proceeding from Observations to Theories, and from Theories to farther trials, which he often asserted to be the most proper method to succeed in the interpretation of Nature. For these, his happy Qualifications, he was much respected by the most learned Philosophers both at home and abroad: And as with all his Failures, he may be reckon'd among the great Men of the last Age, so had he been free from them, possibly, he might have stood in the Front. But *humanum est errare.*

[But has not the success of his Methods and Inventions placed him in front of his great contemporaries? thus showing that Dr. Waller was also but *human.*]



THE ANCHOR ESCAPEMENT.

*

THE WORK OF

DR. ROBERT HOOKE

1655.

Assistant to Dr. Willis at Oxford.

When twenty years of age ROBERT HOOKE was engaged as assistant to Dr. Thomas Willis, to make chemical preparations, which that eminent doctor doubtless found serviceable in his practice. At the same time he made the acquaintance of several of those men of science, then in residence at Oxford, who seven years later took part in the foundation of the Royal Society, as has been recounted in the preceding *Life*.

1656–1657.

The Anchor Escapement.

No inventions have had a greater influence upon our modern life than those associated with accurate time-keeping, and punctuality. The writer of the most recent work on Horology[1] gives 1656 as the probable year of the invention of the Anchor or Recoil Escapement by HOOKE, almost immediately after the introduction of the pendulum. This invention superseded the use of the Verge or Crown Wheel; and up to the present time has remained the most used form of escapement in domestic clocks: there has, moreover, been very little deviation from the original design.

[1] J. E. HASWELL, *Horology*.

1658.

Regulation of Pocket Watches.

The date 1658 inscribed in a watch with two balances that was made by T. Tompion for Charles II in 1675, has been produced as evidence of Hooke's early work on the regulation of Pocket Watches by Balance wheels. The matter has been discussed in detail by Dr. William Derham (see p. 19), who also attributes the invention of a special *Cutting Engine*, probably for wheel cutting, to Hooke.

1658–1659.

The Air Pump.

The passage in which Hooke claims a share in Boyle's Pneumatic Engine has already been quoted (p. 8). But in a matter of such importance, it is well to examine Boyle's own acknowledgement. Indeed had it not been for Hooke's skilled assistance, it is doubtful whether Boyle would have been able to accomplish anything remarkable on the subject of the 'Spring of the Air'.

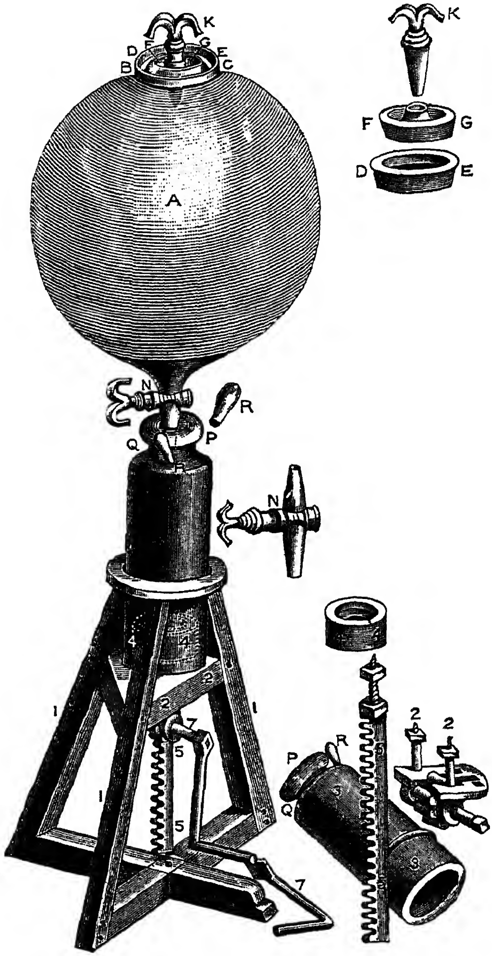
'As few inventions happen', Boyle wrote, 'to be at first so compleat, as not to be either blemished with some deficiencies needful to be remedied or otherwise capable of improvement: so when the Engine we have comes to be more attentively considered, there will appear two very considerable things to be desired in it.

'For first, the *Wind Pump* (as somebody not improperly calls it) is so contriv'd that to evacuate the Vessel, there is required the continual labour of two strong men for divers hours. And next, (which is an imperfection of much greater moment) the Receiver or Glass to be employ'd, consisting of one entire and uninterrupted Globe and Neck of Glass; the whole Engine is so made, that things cannot be convey'd into it, whereon to try Experiments. So that there seems but little (if anything) more to be expected from it, than those very few *Phænomena* that have been already observed by the Author and recorded by Schottus.

'Wherefore to remedy these Inconveniences, I put both Mr. G[ratorix] and R. Hook (who hath also the honour to be known to your Lordship,[1] and was with me when I had these things

[1] Lord Dungarvan, nephew of Robert Boyle.

under consideration) to contrive some Air Pump, that might not like the other, need to be kept under water (which on divers



Hooke's Pneumatic Engine or Air Pump.
As constructed for Robert Boyle and used by him in his Laboratory in the High Street in Oxford.

occasions is convenient) and might be more easily managed. And after an unsuccessful tryal or two of ways propos'd by others, the last named Person fitted me with a Pump, anon to be described.

And thus the first imperfection of the German Engine, was in good measure, though not perfectly remedied.'

After a detailed description of the Engine, BOYLE continues: 'Your Lordship will, perhaps, think that I have been unnecessarily prolix in this first part of my Discourse. But if you had seen how many unexpected difficulties *we* found to keep out the external Air, even for a little while, when some considerable part of the internal had been suck'd out, you would peradventure allow that I might have set down more circumstances than I have, without setting down any, whose knowledge, he that shall try the experiment, may not have need of. Which is so true, that, before we proceed any further, I cannot think it unseasonable to advertise Your Lordship, that there are two chief sorts of Experiments which *we* designed in *our* Engine to make tryal of.' [1]

It will be noticed that Boyle has here scrupulously acknowledged the help he has received from HOOKE. Moreover he is apparently always striving to make an honest use of the first personal pronoun, always using the plural forms 'we' and 'our', when others participated in his experiments.

Though HOOKE had to get the cylinder of his pump bored in London, the designing and construction were executed in Oxford in the house on the west side of University College, which I identified and illustrated in the first volume of this series.[2] No more important work has ever been done in Oxford, for the making of that Pneumatic Engine prepared the way for the successful construction of the Atmospheric Engine of NEWCOMEN, of the Steam Engine of JAMES WATT, of the myriads of air, gas, steam, petrol motor-engines of to-day.

In the realm of pure Physics, it has not been less important. The Experiments on the Spring of the Air within a few months supplied the proof of the proportional relation between volume and pressure, commonly known as 'Boyle's Law', or, after its confirmation by MARIOTTE in 1676 as 'Mariotte's Law' or as 'Boyle and Mariotte's Law'.

[1] R. BOYLE, *New Experiments Physico-mechanical touching the Spring of the Air and its Effects, Made for the most part in a New Pneumatical Engine.* Oxford, 1660.

[2] GUNTHER, *Early Science in Oxford*, vol. i, p. 11.

We wish to claim for ROBERT HOOKE some share in the discovery of this Law of Gaseous Pressures and Volumes.

The full setting forth of the Hypothesis is in BOYLE's famous 'Defence against Linus'. In this tract too, he uses both personal pronouns 'I' and 'we', but gives no name to his co-experimenter. Now, at the time, as is not very widely recognized, BOYLE needed help badly. He was suffering from weakness of eyesight. Without help he could have done nothing. He records that when 'noble experiments' had to be made in very elevated places, 'we did with the assistance of an ingenious man attempt a Tryal', 'but instead of a common tube we made use of a kind of Weather-glass, that the included Air might help to make the event notable'. The experiment was carried out on the Leads of the lofty Abbey Church at Westminster and also in the Gallery of the same height as the Leads—a locality probably well known to HOOKE as an old Westminster Scholar. On another occasion, he records 'We took then a long Glass-tube, which by a dexterous hand and the help of a Lamp was in such a manner crooked at the bottom, that the part turned up was almost parallel to the rest of the tube'.

Again he notes that certain discrepancies were probably due to included air which 'we guest to have come from some little Aërial bubbles in the Quicksilver, contain'd in the pipe (so easie is it in such nice Experiments to miss of exactness)'. Here BOYLE says '*we*' guessed; with his poor sight he would hardly have noticed the air-bubbles himself, and no ordinary assistant would have perceived their significance.

Here, again, we may imagine the helpful presence of HOOKE. It is however one thing to observe accurately, but another to deduce a Law from the observations. BOYLE not only complained of failing sight, but also of lack of skill in Geometry, which made him 'both unwilling and unfit to engage in any Study where the conversing with Mathematical Schemes is necessary'.[1] The results were tabulated in a 'Table of the Condensation of the Air under various Pressures' and BOYLE summed up as follows: 'All that I shall now urge being, that the trial already made sufficiently proves the main thing for which I here allege it; since by

[1] Preface to *A Defence of the Doctrine touching the Spring and Weight of the Air*. London, 1682.

it 'tis evident, that as common Air when reduced to half its wonted extent, obtained near about twice as forcible a spring as it had before, so this thus comprest Air being further thrust into half this narrow room, obtained thereby a Spring about as strong again as that it last had, and consequently four times as strong as that of the common Air.'

Is it too extravagant an assumption that his chief assistant throughout was ROBERT HOOKE? And if HOOKE had been BOYLE'S assistant during the experiments, may we not also assume that as his was a mathematical mind, whereas BOYLE'S qualities lay in other directions, is it not probable that the first suggestion of 'Boyle's Law' came from him?

1660

We have no evidence that HOOKE attended any of the preliminary meetings that were held before the foundation of the Royal Society, but it is more than likely that he may have attended some of the early gatherings of the men of science assembled in Oxford and have shown experiments at them. In view of the fact that he was appointed Curator of that distinguished Society at an early date, it is of interest to note that before his appointment, indeed before the new Society had obtained a Charter and could thereby claim the title 'Royal', the relationship of the Curator to an Operator had already been clearly defined.

Dec. 12, 1660. At a Preliminary Meeting it was agreed that the salary of the Operator be four pounds a year; and for any other service, as the Curators, who employ him, shall judge reasonable.[1]

Capillary Attraction.

The first paper published by HOOKE dealt with problems of Capillary Attraction. It is said to have been written and published in 1660, but whether this be so or not, the preceding research would probably have been carried out in Boyle's Laboratory in the Oxford High Street in or before 1660.

The paper was illustrated by a plate of figures (p. 77) that were undoubtedly drawn by HOOKE himself. They are somewhat rough, and were reproduced in finer line, as Plate IV of *Micrographia* in 1665.

[1] BIRCH, *History of the Royal Society.*

An
ATTEMPT
FOR THE
EXPLICATION
Of the
PHÆNOMENA,
Obſervable in an Experiment Publiſhed by the Honourable
ROBERT BOYLE, Eſq;
In the XXXV. Experiment of his Epiſtolical Diſcourſe touching the *AIRE*.

In Confirmation of a former Conjecture made by *R. Hooke*.

Nos cum non ſemper magna referre poſſimus, vera tamen ſed rara recitamus; neq; enim minori miraculo in parvis Natura ludit quam in magnis, Cardan de Vari. *L.8. Cap. 43.*

Tum vero de Scientiarum progreſſu ſpes bene fundabitur, quum in hiſtoriam naturalem recipientur & aggregabuntur complura experimenta, quæ in ſe nullius ſunt uſus, ſed ad inventionem cauſarum & axiomatum tantum faciunt, Verulamii Nov. Org. Aph. 99.

LONDON,
Printed by *J. H.* for *Sam. Thomſon* at the Biſhops Head in St. *Pauls* Church-yard, 1661.

TITLE-PAGE TO HOOKE'S FIRST SCIENTIFIC TREATISE.

1661

(1) *An attempt for the explication of the Phaenomena observable in an Experiment, published by the honourable* Robert Boyle *Esq; in the xxxv Experiment of his Epistolical* Discourse touching the Aire, *In confirmation of a former conjecture made by R. H.* 8vo. London, 1661.

Capillary Attraction.

April 10. That the subject of the next debate be Mr. ROBERT HOOKE's tract, printed in 1660, concerning the cause of the rising of water in slender glass-pipes higher than in larger, and that in a certain proportion to their bores.[1]

The amanuensis was ordered to make several crooked glasses with bubbles at the end.

New Measuring Instrument.

HOOKE's second publication is said to have appeared in the same year: it is entitled

(2) *A discourse of a New Instrument to make more accurate observations in Astronomy, than ever were yet made.* 4to. London, 1661.

Wandring Mite.

Sept.–Oct. HOOKE observed Mites in Oxford. *Micrographia*, p. 205.

Aug. 2. Experiment on Atmospheric Pressure. *Micrographia*, p. 225.

1662

Pendulum Clocks at Sea.

At some time during this year certain Pendulum Clocks were tried at sea by Lord KINCARDINE, and Mr. HOOKE was present.

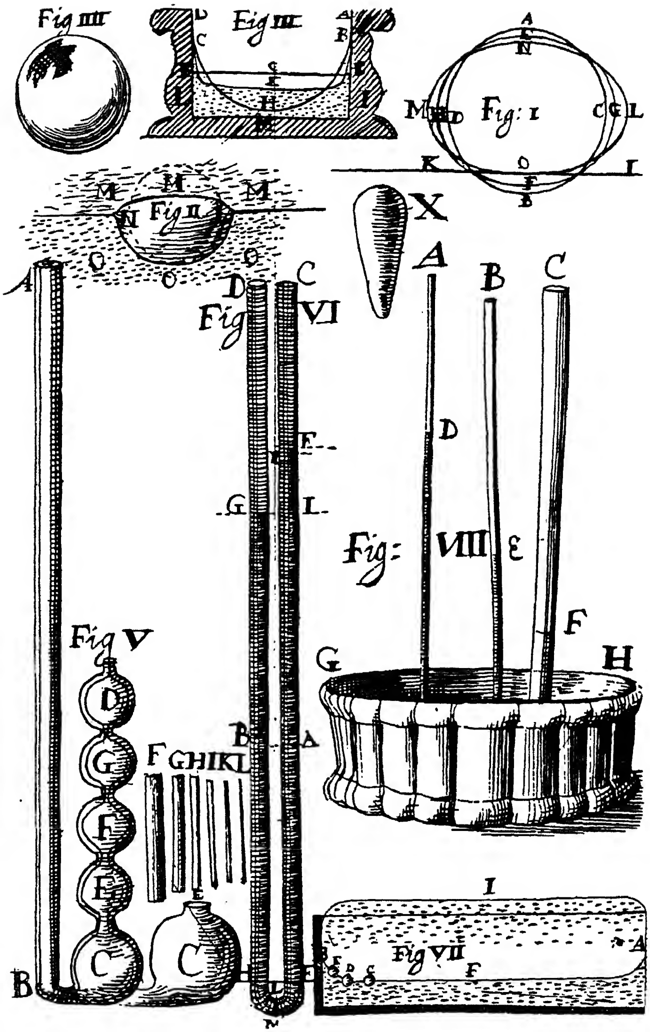
Hooke nominated Curator of Experiments.

Nov. 5. Sir ROBERT MORAY proposed a person willing to be employed as a Curator by the society, and offering to furnish them every day on which they met, with three or four considerable experiments, and expecting no recompense till the society should get a stock enabling them to give it.

The proposition was received unanimously, Mr. ROBERT HOOKE being named to be the person.

Nov. 12. Sir ROBERT MORAY proposed Mr. HOOKE as a Curator of Experiments to the society; who being unanimously accepted

[1] See Mr. WALLER's Life of Dr. HOOKE, p. 22 *ante*.



FIGS. I–IV. Experiments on the deformation of spherical globules by pressure of the denser media on or in which they rest.

FIG. V. V-tube with bulbs for experiments on surface tension. F–L Capillary tubes.

FIG. VI. Experiment with water and oil.

FIG. VII. Experiment to show the approquination of floating bodies and their incursion against the sides of the containing vessel.

FIG. VIII. Experiment to show rising of water in capillary tubes.

of, it was ordered, that Mr. BOYLE should have the thanks of the society for dispensing with him for their use; and that Mr. HOOKE should come and sit amongst them, and both bring in every day of the meeting three or four experiments of his own, and take care of such others, as should be mentioned to him by the society.

Breaking Glass Bubbles by Air Pressure.

Nov. 19. Mr. HOOKE made the experiment of breaking several glass bubbles with rarefied air, and nipped up; of which some broke with a brisk noise, others not. He was desired to bring an account in writing of this experiment to the next meeting; as also to make the experiment of weighing the same glasses, first with the rarefied air, and afterwards with the common air admitted into them, when unsealed.

Condensing Engine.

He undertook to show an experiment about the tenacity of air; and acquainted the society with an engine, which he had, for trying many experiments of condensation; which engine was desired to be made as soon as might be.

Experiments with vacuous Glass Balls.

Nov. 26. Mr. HOOKE brought in his account of the experiments tried with glass-balls: 1. Of driving out the air by heat only. 2. Of driving it out by vapours. 3. Of their breaking of themselves. 4. Of their breaking by a knock. 5. Of the quantity of water they admitted. 6. Of the weight of the air admitted. 7. Of their shrinking and stretching. 8. Of their breaking outwards. Which was read, and was as follows: [1]

A small tube of white glass melted in the flame of a lamp was blown into a pretty large ball (near the size of a tennis-ball) the small neck or pipe of which being, whilst the ball was yet red hot, suddenly and carefully sealed up hermetically; I observed, that these balls or bubbles being left to cool, some of them, that were either not very equally or over thin blown, would in the cooling break inward with a brisk and loud noise; some sooner, whilst yet hot; others later, when even quite cold; but these latter yielded much the louder report. Some, that were strong and even blown, remained entire when quite cold; the which balls I observed to endure a much greater and more violent blow before they would break, than others much of the same make, which were left to cool without sealing up. But when with a pretty brisk blow they were broken, they yielded, besides the noise of the blow, sometimes a smart, at other times a more faint noise. Some of these bubbles, whilst thus hermetically sealed,

[1] It is printed in his *Philosophical experiments and observations*, published by W. DERHAM, F.R.S., pp. 9–13. Edit. London 1726, 8vo.

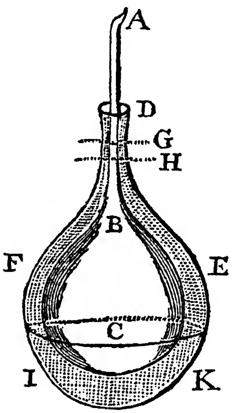
being poised in a pair of exact scales, and the little sealed end nipped off and put into the same scale, a sibilus or hissing noise might very easily be heard to ensue for the short space of about half a second of time; after which the same scales and counterpoise being left free, the bubbles were always observed to preponderate, some by $\frac{1}{4}$ of a grain, others half, and others more. The ends of some other of these being broken off under the water, the water was observed to ascend with a very great impetuosity, and when within the ball, to look white, until such time as it had filled the bubble or ball about $\frac{2}{3}$ or $\frac{3}{4}$ of the whole capacity; some more, some less, according as the balls were more or less hot when sealed up. Holding the balls of some of these unsealed bubbles over the flame of a candle, till the water was boiled or exhaled away (rushing out very impetuously through the small stem) I immediately sealed up the small end again, and observed some of them to break with a much louder crack than those, that had been sealed up when red hot. One, that had a very small passage through the neck, being kept too hot in the flame, burst outward with a very great violence and noise. Breaking off the tips of others under water, I found a much greater quantity of water to enter, in so much as to fill almost the whole ball, leaving a very little bubble of air at the top. Others that I weighed I found to increase more in weight by the admission of air, than they had done before the other sealing.

After this, having emptied out the water, I put into some of them a small quantity of indifferently well rectified spirit of wine, and holding the ball over the flame of a lamp, till the spirit with great impetuosity was evaporated and driven out (which I presently perceived, by the ceasing of the vapours at the tip) I sealed up the tip, and proceeding as with those I tried with water, I found these to differ very little from those, both as to the noise they yielded, and in their admitting of water, and as to the weight of the air. Both these two last ways I found to differ from the first, in this, that whereas the red-hot glasses, when cold, were clear, these, though they appeared clear when hot, were notwithstanding all tarnished over with a kind of dew in the insides when cold; which dew would quickly disappear, if they were again heated pretty hot. There were several other circumstances, which because they will be more notable in other experiments, I here omit.

A conjecture at the causes.

First, That the elastical power of the exceedingly heated parts of the air, that are within the ball of the glass, when red hot, being very much intended, a very small parcel is able to press and keep out all the rest of the ambient contending atmosphere;

even as in the next place a small parcel of water, or spirit of wine, rarefied into vapours by a not very strong heat, is likewise able to do. Now whilst the air is thus thrust and kept out, the passage being firmly shut, the ambient air is hindered from rushing in that way, though the heat within the ball decreasing, and so likewise the elater both of the air and vapour (the latter for the most part returning or falling back into their pristine forms of water or spirit of wine, and so sticking about the insides of the bubbles) would not have been able to have hindered its rushing in. Now the pressure of the included body against the insides of the glass (whether air or vapours) decreasing with its elater, and that with the heat, and the pressure of the ambient remaining the same, that curious arched vault of the glass is forcibly pressed and crushed together, and so the particles are put into a closer texture. Now the difference of the internal and external pressure increasing by the decrease of the included air's elater, if some parts of this arch (if I may so call it) be weaker than the rest, or irregular, the ambient pressure breaks it in; even as in architecture, the same would happen in those larger vaults, if in either of these particulars they deviate from the rules of that art. But if they be sufficiently strong and equal, the ambient pressure makes the crystalline vault the firmer, as in arches of stone is commonly observed.



Now that the parts of glass are pressed closer together, I found by this experiment: I fitted a pretty large bubble with a slender neck (such as ABC in the figure) into a bolt-head DEF, whose neck D was drawn very small, and only left big enough to contain the neck AB of the bubble, and whose bottom I K was cut off, that thereby the ball might be included. Having thus fitted the ball into the bolt-head, I shut on the bottom again with cement, and filling up the space left in the bolt-head with water, till it reached into the small of the neck as high as H; I nipped off the sealed top of the bubble A, whereupon the water in the small neck rose about $\frac{1}{8}$ of an inch from H to G, which could proceed from nothing else than the relaxation or return of the compressed parts of the included ball, to its former dimensions and positions they were left in before the ball was sealed up; which, by the way, affords an instance of compression, wherein that so hard and exactly uniform body of glass is compressed into less room, and that by no greater pressure than that of the incumbent atmosphere; which, when most with

us in England, is no more than the pressure of quicksilver thirty inches thick or high; a very good argument, that other bodies which are not so uniform and hard, are not without many interstitia or pores: and whether water and other fluid bodies may not suffer the like compression, trial will inform. The cause of the noise I dare not yet determine, but I think it worth a further inquiry, whether it proceed not from the impetus, wherewith the broken pieces of glass are dashed against one another, though the noise seem of another kind; or, secondly, from the sudden rushing of all the parts of the ambient air towards the middle of the ball, whereby all the other parts of the circumambient air being likewise moved towards the same middle, each hinder part succeedeth into the space deserted by the former, till the air within the drum of the ear endeavouring to succeed into the place of that without, may thereby move the film, and so cause the sound to be heard; or, thirdly, which seems to be most plausible, from the sudden and violent rushing toward the centre, and (by there meeting each other, or at least the broken pieces of glass) as sudden and violent recoil: one of which two last (if not a fourth, namely, the sudden flying out of the air) seems to be the reason of the noise of a discharged shot of powder. The alteration, as to weight, does clearly enough proceed from the admitted parts of the air, whose admission the hissing noise plainly speaks: a manifest experiment, that air doth gravitate in air. The violent rushing in of the water argues the forcible pressure of the external, as the multitude of bubbles do the languid resistance of the included air.

The experiments suggest these queries:

1. By what means heat rarefies and expands [and cold condenses] bodies?
2. The strength of a knock, or the force of falling bodies?
3. What may be the cause of noise or sound?
4. Whether the causes of the almost similar phenomena of the glass drops may not be deduced from these principles? or what may be their causes?
5. What is the weight of air in winter?

This paper was ordered to be considered at the next meeting, and the author desired to show then the several experiments mentioned in it, and to have ready a scheme in great of the glass vessels, by which he endeavoured to prove, that the parts of glass were pressed close together.

Experiments of Freezing.

He was desired likewise to think upon some experiments of freezing.

Weighing Air.

Dec. 3. Mr. HOOKE made the experiment of weighing rarefied and common air in little glass-bubbles; and the difference was found to be near $\frac{1}{2}$ a grain in one of them, and above $\frac{1}{2}$ a grain in another.[1]

Expansion of Air.

He also brought in an account of measuring the expansion of the air, viz. what proportion the decrease of its force holds to its increase of dimension; the reading of which was deferred till the next meeting.

Weighing Bodies in Motion in Water.

He proposed, for that meeting, the experiment of weighing ascending and descending bodies in water, viz. what weight they add to the vessel containing the water.

Experiment of Water freed from Air.

He was desired to prepare also for the making of the experiment of water freed from air; which, according to Mons. HUYGENS, does not descend in the cane, after the air is exhausted out of the receiver.

Rarefaction of Air.

Dec. 10. Mr. HOOKE's account of the rarefaction of air was read, and ordered to be registered,[2] as follows:

I took a small and indifferently even-drawn tube of glass, about six foot long, and less than $\frac{1}{4}$ of an inch in the hollow, that was open at both ends; and having by a small list of paper, that was pasted upon it, divided it into inches, halves and quarters, I put it into a bigger glass-tube, that was hermetically sealed at one end, and big enough to contain the former. Then I fastened them perpendicularly against the side of the wall, and filled them together to the top with quicksilver; then letting the small one rise, till it ascended somewhat more than four inches above the surface of the mercury in the greater, I carefully sealed up the upper end of it with hard sealing-wax, and letting it cool for about half an hour, I lifted up the smaller tube, till the air was expanded so as to fill six inches, and observed the subjacent pillar of mercury $10\frac{1}{8}$ inches. Then I lifted it higher, till the air filled full eight inches, and found the ☿ $15\frac{1}{4}$ inches. And so pro-

[1] This paper is printed in the *Philosophical Experiments and Observations of Dr.* ROBERT HOOKE, published by W. DERHAM, F.R.S., p. 6.

[2] Cf. R. S. MS. No. 4.

The air's expansion.	The ☿ height.
4	00
6	$10\frac{1}{8}$
8	$15\frac{1}{4}$
12	$20\frac{1}{4}$
16	$23\frac{1}{8}$
20	$24\frac{5}{8}$
24	$25\frac{5}{8}$
32	$26\frac{1}{2}$

ceeding, I collected this table; which by reason the tube (as I afterwards found) was somewhat bigger toward the middle than near the upper end, does not exactly agree with the hypothesis, which supposes the degrees of rarefaction and force to be in reciprocal proportion; though in other experiments of the same kind, that I have formerly tried with a much more exact tube, I have found it to come very near. Afterwards I depressed again the small tube into the greater, and found the air to return to its former dimensions, which assured me, it had not leaked at the top.

This experiment, were there not, first, a great difference as to heat and cold in the upper and lower regions of the air, which perhaps may render some of the upper parts more dense than the lower; and were there not, secondly, a great disparity in the constitution of the air by vapours and exhalations, which as they may by mixing with the parts of the air much augment the gravity, so they much alter the elater or expansive power of the air; this experiment, I say, were it not for these difficulties, would afford us a very desirable help to guess at the height of the atmosphere. For since, by the accurate experiments of Mr. Boyle, we have the height of the atmospherical cylinder, if of an uniform extension 35,000 feet, if we suppose the cylinder divided into 1000 equal parts, each of these would be 35 feet long, did not the elastical power of the air, by reason of the unequal pressure incumbent on each of them, much alter this extension. And did the elater and pressure of the greater cylinder of the atmosphere follow the laws we have observed in this experiment, each of those thousand equal parcels of air would receive an increment (above its length of 35 feet) which may readily be found and expressed by a number in the form of

1000	00000
999	35000
998	17500
997	$11666\frac{2}{3}$
996	8750
995	7000
994	$5833\frac{1}{3}$
993	5000
992	4375
991	$3888\frac{8}{9}$
990	3500
989	$3181\frac{9}{11}$

a fraction, whose numerator is its distance from the surface of the earth, and its denominator the complement of that number to 1000. Thus the lowest division will be $1\frac{0}{1000}$, the first above the surface of the earth $1\frac{1}{999}$, the second $1\frac{2}{998}$, the third $1\frac{3}{997}$, the fourth $1\frac{4}{996}$, the fifth $1\frac{5}{995}$, the sixth $1\frac{6}{994}$, and so till you come to the last; as for instance, the 996 division about the earth will be extended to $1\frac{996}{4}$ of the lowest, the 997 to $1\frac{997}{3}$, the uppermost but two will be extended $1\frac{998}{2}$, the highest but one $1\frac{999}{1}$.

988	$2916\frac{2}{3}$
987	$2692\frac{4}{13}$
986	2500
985	$2333\frac{1}{3}$
984	$2187\frac{1}{2}$
983	$2058\frac{4}{17}$
982	$1944\frac{4}{9}$
981	$1842\frac{2}{17}$
980	1750
	125915
	Fractions 5 prox.

5000 a mile) 125920 Eng. feet ($25\frac{23}{125}$ miles.

and the highest of all $1\frac{1000}{00}$ seems to be indefinite, and may perhaps ascend many hundred miles. And, according to this rule, having cast up the length of some of the uppermost, I found the length or extension of the twenty equal divisions next below the uppermost, to amount to somewhat more than twenty-five miles, as by the table appears. I think it were worth while, by such as have opportunity, to inquire how near experiments made for the finding the air's extension on high buildings or hills, and in deep wells or mines, agree with this hypothesis, and how much it differs. This I am sure, that there may be a very sensible difference found in the pressure of the air at so little a height as thirty-five foot: for I lately made a trial at that height with a convenient vessel, and found an inch difference in a cylinder of water. And this I found constant, by repeating the experiment six or seven times; but in what proportion it expanded, I have not examined.

After this experiment I opened the top of the small tube, and filled up the four inches of space above the ☿ with coarse spirit of wine, and then again I carefully sealed up the top with wax and cement, leaving not the least sensible parcel of air at the top. After this I found, that till I had, by lifting up the small pipe, made the cylinder of mercury about twenty inches high, there scarce appeared any bubble: but then I observed three or four small bubbles to arise from the bottom, which there appeared no bigger than the point of a pin, but ascending grew bigger and bigger, with so strange an increase, that they were as big as peas before they came to the top; which bubbles now kept the spirit of wine from touching the top. Proceeding, I observed this aerial substance to extend itself, and fill half an inch, when the subjacent mercurial cylinder was $26\frac{1}{2}$ inches; the spirit of wine falling four inches. I lifted the tube higher, and found the aerial substance fill $4\frac{1}{2}$ inches, the spirit of wine $3\frac{1}{2}$, the ☿ $28\frac{1}{2}$. I proceeded further, and found the aerial substance 27 inches, the spirit 3, and the ☿ $29\frac{1}{4}$; which clearly evidences, that the aerial substance at the top (though it seemed generated out of the spirit) had an elastical property, since the mercurial cylinder increased in height, as that was more expanded; but whether it were air, I dare not determine. Fastening the small tube at that height I had last lifted to, I observed some rising bubbles to increase more strangely than before; in so much as, when they came to the top,

to throw up the spirit of wine before them three or four inches: many of these I observed to do the same thing. I heated that part of the tube, where the aerial substance was, but found it not depress the ☿; but heating that against the spirit of wine till it began to boil, the ☿ was depressed above an inch; but removing the candle after a little time, the ☿ returned to its former height. This experiment seems to me a good argument, to confirm the hypothesis of the pressure of the air upon the terraqueous globe. For the bubbles, that ascend from the bottom of water, when the top of it is exposed to the free air, do very little, or not sensibly, increase in bulk. And that because their pressure decreases but as 100006, 100005, 100004, 100003, 100002, 100001, 100000, because 100000 (which round number we take for the pressure of the atmosphere) is added to 6, 5, 4, 3, 2, 1, the pressure of the water. Whereas when the 100000, or weight of the atmosphere is removed, the pressure on the ascending bubbles decreases as 6, 5, 4, 3, 2, 1, 0.

Weighing Bodies in Water. Density of Waters.

Mr. HOOKE was desired to make at the next meeting the experiment with quicksilver and spirit of wine, mentioned by him in the preceding paper:

To make that of weighing ascending and descending bodies in water: And

To distil some water, and to see, whether the half of it being distilled weighs as much as the other half remaining in the retort; to find out, whether there be some parts in water subtiler and finer than others.

Air from Spirit of Wine.

Dec. 17. The experiment of expanding the air from the spirit of wine was made, and agreed very nearly with the account given in by Mr. HOOKE in writing concerning it.

Waters.

Mr. HOOKE brought in his account of the diversity of the parts of common water, which was ordered to be registered, as follows.

I took common water, and putting it into a retort, I distilled over a small quantity of it with a gentle fire in a sand-furnace: then taking that, which was distilled over, and some of what remained behind in the retort, with a very exact pair of scales, I examined the weight of either apart, and found that, which was come over, somewhat lighter than that which was behind, though the difference were not very great. Then I weighed common water undistilled, and snow-water, that I carefully gathered, melted, and left to cool and settle. And after all, I tried also the weight of some May-dew, and found (after I had diligently

examined, that all things requisite to this experiment were in a good order, and that I had made my trials twice or thrice) that the weight of these several liquors were in these proportions to each other:

The weight	Of common water undistilled –	$124\frac{5}{16}$
	Of the caput mortuum of common water after distillation – –	$124\frac{5}{16} \times \frac{1}{64}$
	Of the spirit or distilled water –	$124\frac{4}{16}$
	Of the May-dew – – –	$124\frac{4}{16}$
	Of the snow-water – – –	$124\frac{3}{16}$

And this I did after I had found (by equally exposing the liquors to the cool air, and then making trials with a very accurate weather-glass) that the several liquors were very near of the same temperature, as to heat and cold: I say very near, because I found the snow-water, for the most part, somewhat cooler than any of the rest.

These trials do seem to inform us, either that the parts in common water, before distillation, are of a different subtility; and that therefore those, which are more light and volatile are, by a more gentle heat, easier raised up into the form of vapours, and carried over the helm: or, that the parts of common water, if uniform and homogeneous before distillation (that is, before they have been by heat transmuted into the form of vapours) are, after distillation, put into another condition; and are altered themselves, as to their magnitude or motion, and so become more light and volatile: or, are put into a new texture, as to one another, and thereby constitute a liquor much more light and porous. Which way soever therefore of these two we incline to, it will seem to hint to us a difference in the constituent parts of common water, as to their greater or less volatility: for since it is generally believed, that a great part of the waters near the surface of the earth deduce its origin from the sky, whence it is imparted to the earth, sometimes in dews, sometimes in mists, rains, fogs, snows, hail, and the like; it will follow, that some of it has suffered a distillation. And because we find, that common water is heavier than either distilled water, snow-water, or dew; it follows also, that either some parts of it (such as may perhaps be of a sluggish nature themselves, or, though of themselves volatile, may be clogged with saline or terrestrial particles); it follows, I say, that some parts have not suffered a distillation; or have, since their return to the earth, acquired a new constitution, by uniting perhaps with one another, or with some saline and terrestrial parts.

In the experiment therefore, where abundance of bubbles are observed to arise out of the water, after the pressure of the air is removed, I see not why the generation of these bubbles may not

in part be ascribed to the more subtile parts of the water, which, when the pressure of the air is removed, are able to acquire the form of vapours, by that small heat which is left in the ambient air; and may, after they have acquired a new texture, have also a power of persisting in it, as was observable in the remaining expansion of spirit of wine, after the pressure of the air was re-admitted, and that of the factitious air generated by the corrosion of iron in Mr. BOYLE's experiments.

It is worth the observing further in these experiments, that May-dew, commonly accounted the lightest and most volatile of all waters, is yet, by this experiment, found to be no lighter than common distilled water, and heavier than snow-water; and it argues somewhat for the former opinion, of the differing of the parts of water as to volatility; for May-dew, as we have no argument to believe it raised very high, so has it the heat of summer to raise it; whereas snow, as we are assured it descends sometimes from a considerable height, so it has a more languid heat, viz. that of the winter air, to raise it.

Crystallization of Ice.

Mr. HOOKE communicated likewise some remarks on the figures in frozen urine, frozen water, and snow; and those of the small shootings of hoar-frosts; which were ordered to be registered.[1]

Experiments on Weighing and Vapour Pressure.

He was appointed curator of three experiments against the next meeting:

1. Of weighing ascending and descending bodies in water.
2. Of weighing some bodies at the top of Westminster Abbey, and at the foot of it.
3. Of forcing water out of a glass by its own vapours.

Dec. 24. The experiment of weighing ascending and descending bodies in water, and another of driving water out of a glass by its own vapours, were made before the society by Mr. HOOKE; who also brought in the following account in writing of the latter, which was ordered to be registered.[2]

In prosecution of Dr. GODDARD's experiment, brought in December 17, 1662, I tried with small bolt-heads blown in the flame of a lamp, and (though with much trouble) I made a shift to seal up some, after I had driven out the water by the vapours. One of these, after it was quite cold, I broke under water, and found it filled almost full, leaving but a small bubble of air at the

[1] They are printed in his *Micrographia*, pp. 88–93. Cf. 'On the 6-branched crystals of Urine', R. S. MS. No. 5. Also No. 6.

[2] Cf. R. S. MS. No. 7.

top, which bubble remained constantly in the form of air, and did not vanish. I drew out the water likewise out of others, and letting them cool, I always found, that there was left a pretty big bubble of air in the head, which remained so, though I left them standing with their necks in the water for three or four days; but they seemed a little decreased. I tried the bigness of one of these bubbles, and found it, by a very exact pair of scales, to be the 312th part of the whole content of the bolt-head. The bubbles I guess may be generated partly from the water rarefied by heat, and partly from the sudden removal of the pressure of the air after the glass begins to cool, which makes the water rush in with a most admirable violence: I say partly from this last way, because making trial with an open jar inverted into a skillet of water, I found the bubble of air left at the top, by guess, not so big in proportion to the contents of the jar, as the former were in respect of the bolt-head.

Weighing.

He was desired to communicate an account of the experiment of weighing ascending and descending bodies, at the next meeting.

Decrease of Gravity.

He gave in the following account of the experiment concerning the decrease of gravity, by removing the body farther from the surface of the earth upwards: which was ordered to be registered.

In prosecution of my lord VERULAM's experiment concerning the decrease of gravity, the farther a body is removed below the surface of the earth, I made trial, whether any such difference in the weight of bodies could be found by their nearer or farther removal from that surface upwards. To this end I took a pair of exact scales and weights, and went to a convenient place upon Westminster Abbey, where was a perpendicular height above the leads of a subjacent building, which by measure I found three-score and eleven feet. Here counterpoising a piece of iron (which weighed about sixteen ounces troy) and packthread enough to reach from the top to the bottom, I found the counterpoise to be of troy-weight seventeen ounces and thirty grains. Then letting down the iron by the thread, till it almost touched the subjacent leads, I tried what alteration there had happened as to its weight, and found, that the iron preponderated the former counterpoise somewhat more than ten grains. Then drawing up the iron and thread with all the diligence possibly I could, that it might neither get nor lose anything by touching the perpendicular wall, I found by putting the iron and packthread again into its scale, that it kept its last equilibrium; and therefore concluded, that it had not received any sensible difference of weight from its near-

ness to or distance from the earth. I repeated the trial in the same place, but found, that it had not altered its equilibrium (as in the first trial) neither at the bottom, nor after I had drawn it up again; which made me guess, that the first preponderating of the scale was from the moisture of the air, or the like, that had stuck to the string, and so made it heavier. In pursuance of this experiment, I removed to another place of the Abbey, that was just the same distance from the ground, that the former was from the leads; and upon repeating the trial there with the former diligence, I found not any sensible alteration of the equilibrium, either before or after I had drawn it up; which further confirmed me, that the first alteration proceeded from some other accident, and not from the differing gravity of the same body.

I think therefore it were very desirable, from the determination of Dr. Power's trials, wherein he found such difference of weight, that it were examined by such as have opportunity, first, what difference there is in the density and pressure of the air, and what of that condensation or gravity may be ascribed to the differing degrees of heat and cold at the top and bottom, which may be easily tried with a common weather-glass and a sealed-up thermometer: for the thermometer will show what of the change is to be ascribed to heat and cold, and the weather-glass will show the differing condensation. Next, for the knowing, whether this alteration of gravity proceed from the density and gravity of the ambient air, it would be requisite to make use of some very light body, extended into large dimensions, such as a large globe of glass carefully stopped, that no air may get in or out: for if the alteration proceeded from the magnetical attraction of the parts of the earth, the ball will lose but a sixteenth part of its weight (supposing a lump of glass held the same proportion, that Dr. Power found in brass) but if it proceed from the density of the air, it may lose half, or perhaps more. Further, it were very desirable, that the current of the air in that place were observed, as Sir Robert Moray intimated the last day. Fourthly, I think it were worth trial to counterpoise a light and heavy body one against another above, and to carry down the scales and them to the bottom, and observe what happens. Fifthly, it were desirable, that trials were made, by the letting down of other both heavier and lighter bodies, as lead, quicksilver, gold, stones, wood, liquors, animal substances, and the like. Sixthly, it were to be wished, that trial were made, how that gravitation does decrease with the descent of the body, that is, by making trial, how much the body grows lighter at every ten or twenty feet distance. These trials, if accurately made, would afford a great help to guess at the cause of this strange phenomenon.

Weighing in Water.

Dec. 31. Mr. HOOKE made again the experiment of weighing ascending and descending bodies in water, but in another manner; and was desired to bring to the next meeting an account of it in writing.

Experiments proposed.

Mr. HOOKE proposed the following experiments to be made at the next meeting, viz.

1. To show the difference in the refraction of warm water and cold;
2. The difference in the weight of warm water and cold;
3. The living of insects in condensed air:

Combustion.

To which he added a suggestion concerning the rarefying of chimneys, or the ways of ordering the combustible materials so, as that with a smaller consumption of the fuel, a greater heat may be given, than is done by the common ways yet in use.

1662/3

Refraction and Density of Hot and Cold Water.

Jan. 7. Mr. HOOKE made two of the experiments proposed by him at the preceding meeting, viz. that of the difference of the weight of warm and cold water; and that of the difference of refraction in warm and cold water: which latter he was desired to repeat at the next meeting, when he was also to make the experiment of the living of insects in condensed air; and to bring in an account of all in writing.

He gave in his account of some trials for finding how much the pressure of water is increased by the descent of heavier, or the ascent of lighter bodies therein: the reading of which was deferred till the next meeting.

Glass making.

He was directed to show the society the way of making, with a lamp, coloured glass out of white glass.

Experiments proposed.

Mr. HOOKE proposed two experiments for the next meeting, viz. 1. Of the force of descending bodies from different heights: 2. Of compressing air by quicksilver.

Combustion.

He desired again, that those members, who were acquainted

with the ways of ordering fuel to the best advantage, might bring in an account thereof, in order, that, upon consideration of what had been done hitherto in that matter, it might be further considered how to improve it. Whereupon, several members suggested what came into their minds.

Density of Hot and Cold Water.

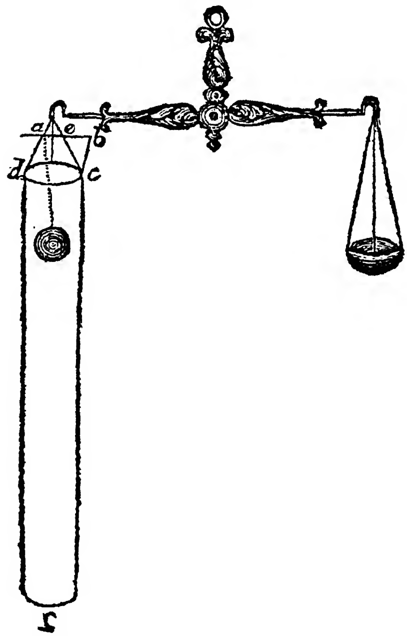
Jan. 14. Mr. HOOKE's two papers were read, the one containing an account of some trials for finding how much the pressure of the water is increased by the descent of heavier, or the ascent of lighter bodies therein.

An account of some trials for the finding how much, ascending and descending bodies press upon the medium through which they pass: made before the Royal Society, Dec. 24, and Dec. 31, 1662. [Derham, pp. 14–18. The original figures are in R. S. MS. 9, dated Jan. 14, 1662/3.]

A glass tube about fourteen inches long, and an inch and half over, being open above, but shut beneath, was hung by a piece of tape fastened about the end of it, to the end of a beam; then being fill'd with water, and a round glass ball somewhat more than an inch in diameter (which was made heavier than water, by quicksilver included in it) being hung by a string of silk so far within the tube, that it was quite covered with water. The other end of this string was tied to a wire, that was fastened to the end of the tube. This tube, I say, thus accoutred, being hung at the end of an exact beam, was counterpois'd with somewhat more than 36 ounces troy. Then the scales being in a very exact equilibrium, the silk string, by which the ball hung, was suddenly cut asunder with a sharp pair of scissers. And the beam, all the while the ball was descending through the water, and after it came to the bottom, kept its former horizontal parallelism. This was repeated a second time with the like success.

At the same time in the same tube, as it hung in this posture, there was let down to the bottom of it a small piece of lead, which had a small loop of wire, through which a silk string being put, a round glass ball much lighter than water, and about the former's bigness, was, by that string, drawn down, and kept at the bottom of the water, and the other end of the string was fastened about the former wire. This done, the scales were brought to an equi-

librium, and then, as before, the thread was cut, and the ball quickly ascended to the top; in which time the beam was observ'd to be very much turned from its equilibrium, and upon trial six grains, detracted from the counterpoise, was requisite to bring them to an equilibrium. This last experiment was twice repeated, but in the latter trial the parallelism of the scales was not at all



disturb'd, as in the former experiment; which gave occasion for a conjecture, that the former odd phenomenon was caused by some extraordinary accident.

In prosecution of this enquiry, *Dec.* 31. trial was made by a variation of the former experiment; for the thread of silk that the ball hung by, was not tied to the former wire, but to a *sustentaculum* above the beam; then the scales being brought to an equilibrium, and the string cut as before, the descending ball made that end of the beam, to which the tube hung, to be exceedingly depress'd, and being come to the bottom it kept the beam in that posture.

Further, that it might be known how much heavier that end

was than the other, whilst the ball lay at the bottom, the beam was brought to an equilibrium; after which, six grains were taken from the counterpoise of weights. Then the ball being tied by a string as before, and the scale wherein the weights hung being kept up to a convenient height, that the beam might hang parallel to the horizon, and the string cut as before, the descending ball was observed manifestly to depress the tube end. Trial was made a third time by counterpoising and ordering all things, as in this second trial, and detracting only three grains, notwithstanding which, the descending ball manifestly depress'd the tube end; which last trials were a confirmation of the first experiment, when the ball was hung to the wire.

These experiments seem to hint this axiom, that every body, whether ascending or descending in a fluid body, does add so much weight or pressure to that fluid body, as its own weight amounts to, and not as much as the weight of so much of the fluid as is equal in bulk to what the moved bodies amounts to.

This I should have put as an axiom, did not some difficulties suspend my assent.

First, since the swifter a body is moved, the greater resistance it finds from the medium through which it passes, and consequently the stronger is its pressure against that fluid; and since descending bodies grow swifter in their motion, the lower they descend, it seems rational to judge, that the descending ball's pressure, on the water, should be increased with its swiftness.

Next, since the body that hinders its motion is a fluid, it seems somewhat difficult to conceive, how the pressure of a descending body can be communicated to the bottom, since the parts of the fluid are circulated. And no less difficult is it to say, on what part of the bottom the pressure rests; whether on the whole, or only that part immediately subjacent to the falling ball; for which way soever is taken, there are several difficulties somewhat hard to be explicated.

Thirdly, if the weight of the descending body be all the while sustained by the fluid, and consequently by the bottom, how comes the body, when it touches the bottom, to press with more force than its own weight; as is evident, in bodies descending through the air.

Fourthly, since the pressure of a fluid body, against the bottom, is greater, or less, according to the height of the surface of the fluid above it: it seems that an ascending body, in water, does manifestly contradict this axiom.

Corollaries, deducible from these experiments, certainly made, may be such as these:

First, that exhalations and vapours press not less upon the surface of the terraqueous globe, when they ascend, than when they are falling; nay, than when they are fallen: the certainty of which, I think, were worth examining.

Next, that the pressure of any contained fluid body, against the sides of the vessel, will be abated by opening an hole at the bottom; though the height of the water be continued the same. That is, that the pressure of a perpendicular height of running water, is not the same with that of standing water.

Thirdly, it should seem, that the pressure of a river, against the pillars of a bridge, is less whilst the water is running between them, than when that passage is stopp'd, though the height in both remaineth the same.

Density of Hot and Cold Water.

Mr. HOOKE's other paper, contained an experiment concerning the different weight of cold and warm water: which paper was ordered to be registered.[1] It was as follows:

A small bolt-head of glass being, by water put into the hollow of it, so poised, that it was but a little lighter than water, was afterwards, at the small end, sealed up hermetically. Then being put into a glass of cold pump water, it remained suspended at the top of the water; and being thrust down to the bottom, it would of itself quickly ascend again to the top, and there remain. This glass of water being set by the fire, whereby the water began to be warm, the ball, within the space of a minute, began to descend, and so continued, till it came to the middle of the glass; where (the glass being at that time removed from the fire, and placed upon a table in the room) it remained suspended. So that if it were by a stick depressed below, or raised above, that middle place of the glass, it would, being let alone, return to it again, till the water again growing colder, it began to reascend to the top of the water, the place from whence it at first descended.

The reasons of which phenomena seem to be these; that the parts of water are, by the action of heat, dissipated, and put into

[1] Cf. R. S. MS. No. 10.

a more loose and rarefied constitution: so that the same parts in this constitution, filling a greater space than they did when less acted on by heat, make up, by consequence, a lighter body, and so are not able to bear up the ball of glass, as they were before that expansion.

That those parts of water, which are heated by the fire, being rarefied, and consequently made lighter than the others that are not so much heated, are by the colder, and consequently heavier parts of the water, thrust up to the top; so that the lighter and hotter being always protruded to the top by the heavier and descending cold ones, which keep near the bottom; these are too heavy to let the ball sink into them, and the upper too light to bear it up; whence the ball remains suspended in the middle, till by degrees the heat in the water decaying, the rarefied parts of the water relapse to the closer and heavier texture, and so bear up the ball to the top of the water.

The uses of this experiment may be some such as these:

First for profit: This might have hinted to a considerate man such an invention, as is published by GLAUBER, of making a bath or stove in a wooden vessel, by the help of some small copper (or other metalline) retort, or such-like body, which will endure the fire. For since that body is kept in a great heat, and the neck of it is inserted in the bottom of the tub; it is clear, that as fast as the water is heated in it, it must be driven out of it, and carried to the top of the water in the tub, by the colder parts of the water, which thrust themselves into its place; whence there arising a continual circulation of the hotter and colder parts of the water, the fire being continued about the metalline retort or body, will quickly heat all the parts of the water in the tub, to almost the same degree with that in the retort. This contrivance, if prosecuted, might perhaps be very beneficial to brewers, dyers, and such other trades, as have occasion to make use of great quantities of water heated; as was lately intimated by Dr. GODDARD.

Next for pleasure and curiosity: This may afford us some hints; as first, of a way of making a weather-glass, whereby the heat and cold of the seasons of the year may be very pleasantly exhibited by the ascending and descending of several bodies, differently poised and shaped into the forms of various animals, as men, birds, beasts, fishes, reptiles, or the like. And secondly, it may afford us a hint of making perhaps a natural perpetual motion; for supposing there was a round hollow ring, or some kind of glass pipe, so bent, that it might return into itself (like the Egyptian hieroglyphic of the year) that had a passage clear round it, so as that a liquor might circulate, without being wasted or leaked out; there might be caused a perpetual circulating motion of a liquor, that should almost fill that pipe; if by

any means it can be contrived to keep one side of that pipe hotter than the other; which would be quickly done, if there can be in nature found two liquors or bodies, whereof the one is ever hotter than the other: for in that side of the pipe, which is enclosed by the hotter medium, the liquor will be ever ascending; and in the opposite, always descending. This will hold in most liquors, and most conspicuously in air; of which I shall have occasion to say more on another subject. Thirdly, it hints a way of poising a body in the midst of a vessel of water; which may likewise be done, by impregnating water with salt; for the saltest and heaviest part of water will subside and remain at the bottom, and that water, which swims at the top, will be much lighter and fresher.

A third use of this experiment may be for caution: For it may hint a thing perhaps worth inquiry, Whether ships, that pass from the northern or polar seas, to those that lie near the torrid zone, will endure to be loaden so deep, as they may for a contrary voyage; since the waters there being hotter, and consequently more rarefied, are not able to bear so great a loading, if this lightness of the water be not counterpoised with the greater abundance of salt, which the hotter water may be impregnated with.

A fourth use of it may be for conjecture: For, to speak hypothetically, it may be supposed, that the vast space of the vortex of the sun or the heavens, wherein the sun, earth, and planets are contained and moved, may be filled with a fluid body, whose parts are of different densities, according as they are nearer or farther from the great fire of the world, the sun, which may be placed in or near the centre of that space, according to the Copernican hypothesis. Next it may be supposed, that the several bodies of the planets and earth may be hollow like so many glass bubbles; and though they appear much more massy than the ambient ether, they may, perhaps, as to their whole bulk, be in an *aequipondium* to the ambient fluid. And so, according as they are more or less massy, they may take their several stations in the fluid ether. Some, such as ☿, ♀, being lighter, may be in an *aequipondium* with the ether near the sun; others, whose crusts may be thicker, and so more massy, as ♄, ♃, &c. may be in an *aequipondium* with the ether farther distant from the sun. And, had I time, I think there is no affection of the planets, but might be illustrated by circumstances of this experiment.

Compression of Air.

Mr. Hooke made the experiment of condensing air by the pressure of water; but the trial not agreeing with the hypothesis, it was ordered to be repeated at the next meeting.

Falling Bodies.

He made an experiment of the force of falling bodies to raise a weight; but was ordered to try it by himself, and then to show it again in public.

Weather-glass Observations.

Dr. MERRET suggested an experiment of keeping two weather-glasses, one in a cellar, the other abroad, to see whether it be colder in cellars in winter than in summer. He was desired to make the trial, Mr. HOOKE furnishing him with weather-glasses.

Economy in Fuel.

Sir ROBERT MORAY and Mr. HOSKYNS related the way of making the burning balls at Liege, &c. which is a thrifty kind of fuel, lasting long, and burning without smoke, and leaving no ashes.

Mr. HOOKE was ordered to consider of the several ways of ordering fuel, that had been suggested, in order to make an improvement thereof.

Loading Ships.

Mr. VERMUYDEN and Mr. STANHOPE mentioned, that the Greenland men do not load their ships so deep in the Greenland seas as they might, because they were apprehensive of sinking, when they should come more southward. It was queried, whether they did this upon the account of thinner and lighter water, or from fear of foul weather.

Mr. STANHOPE, Mr. HOSKYNS, and Mr. HOOKE were desired to draw up some inquiries concerning the said particular of loading ships in Greenland, in order to be sent with the fleet going thither.

Dr. Hooke's Enquiries for Greenland. Jan. 14, 1662/3.

What, and how much, was the heat of the sun in the midst of summer, compared with the heat of it in *England?*

What is the most constant weather there, whether clear, cloudy, rainy, misty, foggy, *&c.*? Or what most usual at such and such times of the year? Next, what constancy or unconstancy there is of the winds to this or that quarter of the horizon, or this or that part of the year? What the temperature of each particular wind is observed to be; and particularly, whether the north be the coldest, if not, what wind is? What wind is observed to bring most ice, and what to make a clear water at sea? What currents there are, how fast, and which way they set? Whether those currents are not stronger at one time of the moon than

another, whether always running one way? What is observable about the tides, spring or neap? Whether the sea ice be salt or fresh? What rivers there are in the summer? What fowl are found to live there, and what beasts; how they are imagined to subsist in the winter; how they breed and feed their young? What vegetables grow there, and whether they yield any fruits? How deep the cold penetrates into the earth? Whether there be any wells, or deep pits, or mines, wherein the water will remain unfrozen at the bottom? How the land trends? And whether the parts, under or near the pole, be there thought to be sea or land? Whether the person made any experiment, about the loadstone or magnetical needle, or any mathematical observations, about the height of the sun and luminaries, or their apparent diameters, or refraction, or the like?

What fish most frequent those seas, and any thing about their fishing, with the usual bigness of whales, *&c.* their strength, the anatomy of their entrails? Whether any people do or have been known to stay there all the winter, and how they do or have shifted? How near any has been known to approach the Pole? What notice he has taken of the moon, *&c.*[1]

Experiments proposed.

Mr. HOOKE proposed to bring in at the next meeting the following experiments: 1. Of the living of insects in condensed air. 2. Of the force of falling bodies. 3. Of respiration. 4. Of the different refractions in cold and warm water.

Compression of Air.

Jan. 21. Mr. HOOKE made an experiment of condensing air by water; of which he was ordered to bring in an account in writing at the next meeting.

The president suggested, that it was to be considered in this experiment, whether the compression of air was made by the weight of the water only? or whether the coldness thereof did contribute to it?

His lordship proposed likewise, that it might be tried, whether the compression in the same experiment holds exactly by 20, 40, 60, 80, or not?

Falling Bodies.

Mr. HOOKE showed the scheme of an instrument for making

[1] Mr. HOOKE's Enquiries for Greenland are printed in his *Philosophical Experiments and Observations*, pp. 18, 19.

the experiment of the force of falling bodies; which was ordered to be made against the next meeting.

Respiration.

He made a trial with a bladder, how long the same air would serve for respiration without the supply of fresh air; and he found, that it served for five inspirations, though with difficulty. He was ordered to try it again, but with a glass; and to bring in the account thereof in writing.

Inquiries for Iceland.

Mr. HOOKE's inquiries for Iceland were read, and ordered to be registered,[1] and recommended by Col. TUKE to the Danish lord, who was lately ambassador in England, and gave the society a visit.

Dr. Hooke's enquiries for Iceland. Jan. 21, 1662/3. [Derham, p. 19.]

How deep the ground is frozen?

What wind is coldest?

What rivers and springs they have?

The anatomy of whales, or other very large fishes.

About the lungs of whales and contrivance of respiration in other fishes and morses?

Concerning the fountain that is hot enough to scald a fowl.

Whether the burning extraordinarily of *Hecla* portend foul weather?

Refraction, whether the seven stars are seen in the *Pleiades?* Whether *Mercury* can be oftener seen than in *England?* The differing heat of summer and winter: how near the moon may be seen to the sun?

An exact observation of the eclipses that happen.

The saltness of the sea-water, by boiling, how much salt it yields?

The height of the quicksilver in the Torricel experiment.

What wind blows most and oftenest?

The usual temperature of the several winds there.

About corruption and preservation of bodies.

What bodies will keep in the snow, what not?

The burning of the mountain, other observations with the

[1] Original Register, vol. ii, p. 108. These inquiries are printed with some variation in Dr. HOOKE's *Philosophical Experiments and Observations*, pp. 19–22.

needle in several places about *Hecla*, or the other fiery mountains, and in other places of that Isle.

The figure of snow, whether hexangular, whether always larger than in these parts?

The usual bigness of hail-stones and figure.

What is observable about meteors, as *Ignis Fatuus*, star-shooting, thunder, and lightning.

What kind of substances are cast out of the burning mountain.

About haloes and rainbows, any thing extraordinary.

What kind of ores, stones, clays, minerals, *&c.* it yields.

Whether there be any of the *Selenitis*, or *Muscovy* glass to be found there.

The declination, inclination, and variation of the magnet in several parts of the Isle, with the distances and latitudes of those places, as near as may be.

Whether the same point of a magnet, that is a pole of that stone here in *England*, will be so there.

Whether the same part of a *Terrella*, that, put upon quicksilver, will lie toward the earth here in *England*, will do so there likewise.

Whether the attractive virtue of the magnet increase or diminish there, in respect of what it is found here.

Which pole is there strongest.

Whether iron be more or less apt to rust there than here.

What living creatures, tame and wild, live and thrive there.

Any thing of that kind strange or remarkable among the beasts, birds, insects, or fishes; as about their generation, living in the winter; for what they are or may be made serviceable; either for burthen, swiftness, furrs, feathers, meat, *&c.*

What kind of vegetables, thrive best in that Island, as trees, shrubs, or plants, and what kind of grounds they thrive best in; what kinds of vegetables the sea yields, differing from our *English*. In what their husbandry differs from ours, and whatsoever of that kind is remarkable.

What woods it yields good for building, shipping, or other necessary uses.

What notable virtues are attributed to this or t'other plant; whether for divination, physick, dying, smell or taste, *&c.*

The seeds of as many as may be gotten together, with their names.

How several creatures subsist in the winter.

What are the predominant colours of animals.

What general change is made on the shipmen, that does not seem immediately to proceed from cold, as what diseases they are most subject to.

The nature, disposition, manners, and customs of the natives.

Their apparel for warmth, housing, victuals, firing, bedding, cookery, and other observables, either actions or utensils, *&c.*

Any notable effects produced by cold, *&c.*

The height of the islands of ice, their depth; whether it be fresh water; whether it seems to be made up of snow, and seem to lie in plates one above another.

Whether spirits appear; in what shapes; what they say or do; anything of that kind very remarkable and of good credit.

How much the celestial bodies are elevated by refraction above their true place.

What currents there are, the time of the tides in several ports; their great rising and falling in several places; any thing notable concerning them.

What condition the body is in that is preserved by snow, whether shrunk or swell'd, or chang'd in colour or taste, *&c.*

Whether quicksilver will congeal.

A bladder full of *English* air carried thither, and one of that island brought back.

Combustion and Respiration.

Mr. HOOKE proposed an experiment against the next meeting of shutting up an animal and a candle together in a vessel, to see whether they would die at the same time or not.

Jan. 28. Mr. HOOKE made the experiment of shutting up in an oblong glass a burning lamp and a chick; and the lamp went out within two minutes, the chick remaining alive, and lively enough.[1]

Relation between Pressure and Volume of Air.

He brought in an account of some trials for finding the pressure of the parts of water upon one another, and the elastic power of the air: which was read, and ordered to be registered, as follows:

For the making these experiments, there was prepared a long glass tube, sealed at one end; which being erected perpendicularly,

[1] These experiments were similar to those made in Oxford by Mayow, which led to the discovery of 'nitro-aerial spirit' or oxygen.

with the sealed end downward, was filled with water, and so fastened against a wall. Then there was taken another tube of glass, which was twelve inches long in the cavity of it, and was sealed at one end, was divided into inches and half-inches, was small enough to pass to and fro in the cavity of the former tube, and was very equally and evenly drawn. Then to the open end of this was tied a small long plummet, heavy enough to sink this pipe to the bottom of the longer tube. And to the other end of this small tube was tied a string, by which it was let down or drawn up, as there was occasion. These things being in a readiness, the pipe being held by the string (and not touched with the hand, because of rarefying the air) was let down gently into the water; and as it descended, the water in the small pipe began to arise, and so increased the lower it descended. The degrees, by which it got into the small tube, according to the several depths it descended to under the water, at Gresham College, were these: The water rose half an inch, that is, the 24 half-inches of water were contracted to 23 half-inches of space, when the under-surface of that air was below the surface of the water 20 inches; to 22 when 37 inches under, to 21 when 58, to 20 when 79; which being a fifth part of a cylinder of water, able to counterbalance the pressure of the air, the whole cylinder may hypothetically be concluded to be near 395 inches, that is about 33 feet.

I did, since that, erect a tube, some thirteen feet long, and fitting all things as in the former experiment, I collected this table A, whose first row of numbers shows the equal spaces, into which the air was extended, and the last shows the height of the water above the under-surface of the air. Since that, in the same tube, standing in the same place, I reiterated the experiment, and collected this following table B; which three observations being so different one from another, may seem to overthrow each other, and the certainty of this kind of experiment in general. But as I cannot vindicate the trial from being guilty of some errors, it being almost impossible to make these trials so accurate, but that there will be some mistake committed (for the error of a hair's breadth in the smaller pipe may make an error of some inches in the longer); as I say I cannot vindicate them, so neither do I believe, that these seeming contrarieties do wholly proceed from the inaccurateness in the process: for since the common air is sometimes under a greater, sometimes a less degree of pressure, the degrees of force requisite

48	00	
47	08½	
46	17	
45	27	
44	36	
43	45½	
42	58	A
41	68¾	
40	80	
39	91½	
38	105¼	
37	117	
36	130½	

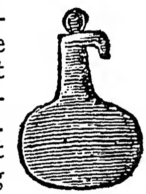
24	00	
23	13	
22	31	
21	52	B
20	76	
19	101	
18	127	
17½	142	

to promote the condensation further must necessarily be differing.

Hence by the first experiment I judge the height of the cylinder of water able to counterbalance the pressure of the air at that time to be near 395 inches, that is about 33 feet. By the second, I judge the counterbalancing pillar then to be between 390 and 400 inches, or near about 33 feet. By the last, I guess it to be about 32 feet.

This experiment therefore, if accurately made at several seasons and times of the year, may afford us a very easy way of knowing the pressure of the air for that time. And this more accurately and nicely, than can be performed with ☿ the ordinary way. For whereas the shortening and increase of the mercurial cylinder is at most not above two or three inches, in this experiment the aqueous cylinder will change fourteen times as much.

Next, this experiment may help us to guess at the pressure of the sea-water against air let down to the bottom of it in a diving-engine, by knowing the proportion between the gravity of salt and fresh water, and the depth, to which the engine is let down: but yet it were very desirable, that such, as have the opportunity of making trials at sea, would be diligent in it. For though there seems to be no doubt, but that the water there does proportionally press according to its perpendicular height, yet it is not easy to predict, how much it may vary from this hypothesis; which deviation may be caused, either by the extreme cold at the bottom of the sea, which may weaken the spring of the air; or from the differing gravity of the upper and lower parts of the salt water; or from somewhat else, whereof we may be yet ignorant.



For the more accurate making of these trials, I think it were requisite to have some such engine as this: Take a good strong glass bottle, that will hold about a gallon, and let there be fitted to it a handsome screw-cover of brass, which may screw very close and tight, that it will not leak water. In the top of this cover let there be made a small hole with a needle-drill, whereby the water may get in, or air get out, as occasion shall require: or, instead of this hole, let there be made a little pipe like that in the figure, whose end may be so turned, as that the hole of it may be open downward. Then hanging a good weight under it, let it sink with the cover upward, to determinate depths, where suffer it to stay for a little space, that the water may be intruded in, as much as the air will suffer it: then drawing up the bottle, and weighing the water it brings up, and repeating the experiments at several depths, it will be easy to give a true account of the pressure of the water at the bottom, without going thither.

There may be many other ways of making this kind of experiment, but this is the most cheap, easy and certain of any I know; nor is there any danger of breaking the bottle either inward or outward. For as the bottle descends, the water rusheth in, and as it is drawn up, the air gets out.[1]

Pressure at Bottom of Sea.

Mention being made in this paper of a diving-glass serving to give a true account of the pressure of water at the bottom of the sea against the air, Mr. HOOKE was ordered to try it in Dr. GODDARD's long wooden tube.

Respiration.

Mr. HOOKE was ordered likewise to procure a glass to be made, that might serve instead of a bladder, to make the experiment of respiration, viz. how long the same air would serve to breathe in, without any supply of fresh air.

Fish.

He was also directed to try, how long fishes will live in the open air, and in a glass full, and exhausted of air.

Falling Bodies.

Feb. 4. The experiment of the force of falling bodies was tried; but the instrument used for that purpose being defective, Mr. HOOKE, the curator of this experiment, was ordered to have it better fitted against the next meeting, and then to repeat the experiment.

Respiration.

The experiment of respiring the same air was made, both in a glass immersed in cold water, and in a bag. Mr. BALLE respired in the glass 30 times, Dr. MERRET 36, Mr. HOOKE 13, the operator 56. But here the time was not observed. Then the same was tried in a bag, where Mr. HOOKE respired 19 times in 1¼ minutes, and Dr. MERRET 76 times in three minutes. It was ordered to be made again at the next meeting, in a glass immersed in warm water.

Water purged of Air.

Monsieur HUYGENS's letter to Sir ROBERT MORAY, dated from the Hague, February 2, 1662/3, was read; and the experiments mentioned therein, viz. that of the quicksilver sticking to the finger, and that of the not subsiding of water purged from air, were recommended to be made again; the former to Dr. GODDARD, in a cane of a less bore than formerly; the latter to Mr. HOOKE.

[1] This report, with some minor modifications, was printed by Derham, p. 96, and is contained in R. S. MS. No. 8.

Refraction of Water and Ice.

Mr. HOOKE mentioning, that the refraction of water is greater than that of ice, he was desired to give an account of that experiment in writing.

Refraction of Ice.

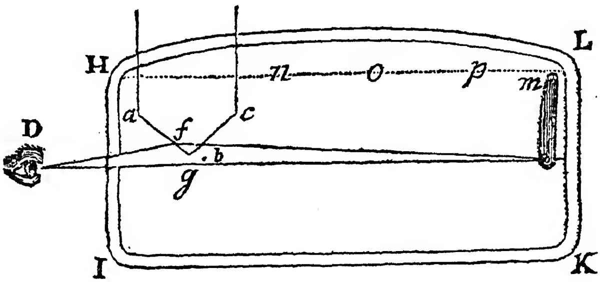
Feb. 11. An experiment of the refraction of ice was made by Mr. HOOKE, and an account of it given by him in writing, which was read, and ordered to be registered.[1] He was desired to try it the next day with a glass of the same figure with the piece used by him in the experiment of this day.

DR. HOOKE'S *experiment before the Royal Society, February 11, 1662/3. about the refraction of ice and crystal.* [Derham, p. 24. R. S. MS. 11.]

Having observed it to be almost a general rule in nature, that of pellucid bodies, those are found to have greatest refraction towards the perpendicular, which are most massy and heavy in bulk, I chose a very pure and pellucid fragment of ice, about an inch thick, which had very few, if any, perceptible blebbs or bubbles in it. Then I took a large cylindrical crystal-glass, about six inches over; and filling it with very fair water, I put into it this clear piece of ice, which did manifestly swim, with several of its parts, above the water; and though I several times depress'd it with my finger, yet would it incontinently rise, as soon as I had remov'd my finger. Then I took it out, and with a very sharp edg'd knife, I shaved one end of it, (which is very easy to do) into the form of a very blunt wedge, so that the two sides of the edge compos'd an angle of about ninety degrees; then smoothing those shaved sides, by rubbing them a little with the palm of my hand, I put it into the water with the edge downwards, and holding it pretty near that side of the glass, which was next my eye, I cou'd plainly perceive, by looking through that edge, that an object, placed against the opposite side, was manifestly refracted. For fastening a small piece of lead, so that the lower end of it reach'd about an inch under water, I could very plainly see that lower end, a little below the bottom, when, looking through the ice, the bottom of it appear'd above the edge of the ice; that is, I saw the same object in two places. Now because the refraction of the ice

[1] Original Register, vol. ii, p. 149. It is printed in *Hooke's Philosophical Experiments and Observations*, pp. 24–6.

made it appear higher than really it was, it shews that the refraction in the ice was less than water; which will more plainly appear by the figure: where H I K L represents the cylindrical glass, that held the water; *m e*, a piece of lead hung against the side of the glass; *a b c*, the blunt edge of the piece of ice; D, the eye; *n o p*, the surface of the water; *f e*, the refracted line, in which the point *e* appeared to the eye; *g e*, the unrefracted. This I several times have repeated, and always found the same.



The use of this experiment may be, 1*st*, for to make an exception from that general rule of M. *Des Cartes*, in the ninth section of the second chapter of his *Diopticks*; where he says, *Quanto firmiores & solidiores exiguæ partes corporis alicujus pellucidi sunt, tanto facilius lumini transitum permittunt.* For, it seems, by this experiment, not to be the greater or less fluidity, or firmness of body, that causes a difference in refraction, but a more rarify'd or condens'd texture.

Next, it affords us two arguments against their opinion, who affirm crystal to be generated of ice. For, *first*, as to its weight, this is found to swim upon water; whereas the other sinks. *Next*, the refraction of crystal is observ'd to be greater than that of glass; whereas this of ice I find to be less than water.

Thirdly, this less refraction of ice, I take to be a good argument, that the lightness of ice, which causes it to be born up of the water, is not caused only by small blebbs or bubbles, but from the uniform constitution, or general texture, of the whole mass.

Force of Falling Bodies.

The force of falling bodies was tried again, and one ounce falling at the distance of less than half an inch, and somewhat more than a quarter of an inch, moved four ounces. The same

weight of one ounce, at the distance of three-quarters of an inch, moved eight ounces; at the distance of an inch and a quarter, moved sixteen ounces; at the distance of about an inch and an eighth, did the same; at the distance of four inches, it moved sixty-four ounces; and at three inches and a little more, did the same.

Mr. HOOKE was ordered to try this by himself at home, as exactly as might be, and to bring in a written account of it at the next meeting.

Eclipses of Jupiter's Satellites.

Dr. POPE was desired to recommend to Dr. WREN from the society the continuance of the observations of the eclipses of Jupiter's satellites; and himself together with Mr. BALLE and Mr. HOOKE to join in the same work.

Respiration.

The experiment of respiration in warm water was made. The operator respired 26 times in 1′ 52″; and Mr. HOOKE 24 or 25 times in 1′ 50″.

Velocity of Falling Bodies.

Mr. HOOKE proposed for the next meeting the celerity of falling bodies.

Eclipse of Moon.

The eclipse of the moon of February 12th was directed to be observed by as many as had conveniency.

Refraction of a Prism in Water.

Feb. 18. The experiment of the refraction of a prism in water was made by Mr. HOOKE; who was ordered to give an account of it in writing.

Force of Falling Bodies.

His account of the force of falling bodies was read, and ordered to be registered, and was as follows:

ABC the pedestal of the scales, DE a double beam, between the two cheeks of which the steel ball F falls from a determinate height upon the steel plate G; and if by that fall it moves the double beam and the counterpoise H, lying in the scale IK, it gives the small spring L a free passage to slip between the end of the double beam and the stay M, by which means there is given a certain sign, whether the falling body has moved the scale and counterpoise so far, as to admit the very thin edge of the spring. The rest of the contrivance is obvious enough from the scheme itself.

This instrument being ready, I put into the opposite scale four

ounces, that is four times the weight of the steel bullet, and letting fall the bullet an inch above the steel plate, I found it to have moved it, and admitted the small spring. I repeated the trials so long, till I found, that letting this ball fall but $\frac{4}{21}$ of an inch above the plate, it would move the beam so as to admit the spring; but if I let it fall from a less height, it would not. Then I put in eight ounces counterpoise, and by several repeated trials, I found $\frac{2}{3}$ of an inch to be the height requisite for the falling bullet to pass before it would move eight times its own weight. I proceeded further, and from the experiments collected the first table A.

A	
$\frac{4}{21}$	4
$\frac{2}{3}$	8
$1\frac{3}{4}$	16
$2\frac{1}{3}$	32
$3\frac{1}{2}$	48
$3\frac{5}{6}$	64
5	96
$6\frac{3}{4}$	128

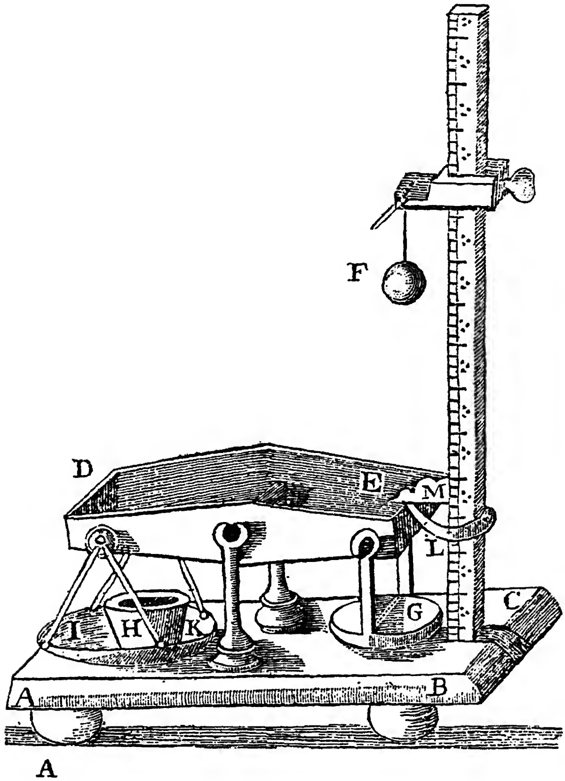
Afterward I took a small ball of clay, that was very round, and exceeding hard (it was in weight very near a quarter of an ounce) and proceeding with this ball as I had done with the steel, I collected from the several trials a second table B. The first row of numbers of both tables show the perpendicular height, from which the balls were let fall to move the several counterpoises, which are noted by the second row of numbers in both tables 4, 8, 16, &c. signifying the counterpoise to be 4, 8, 16 times the weight of the ball.

B	
$\frac{1}{4}$	4
$\frac{3}{5}$	8
$1\frac{4}{5}$	16
$5\frac{4}{9}$	32
18	64
36	128

Which trials, though they do not answer our expectation as to the accurate exhibiting the strength of a moved body, yet seem to prove, that a body moved with twice the celerity acquires twice the strength, and is able to move a body as big again. Nor are the failings in these experiments without some use: for it shows us the difficulty of such trials, where, though all things as to our sense appear the same, yet I find, that sometimes the ball will move the counterpoise, when it is let fall from a less height than is requisite to produce the same effect at another. Whence we need not wonder, if often endeavouring to repeat an experiment, delivered upon good credit, as done by another, with such and such materials, so and so used, though we do all things just according to prescription, yet we miss in producing the promised effect. And therefore, I think it not less useful to show, wherein our present trials were deficient, than to declare what they succeeded in.

One defect therefore in our trials seems to be, that there is a yielding in the materials we made use of; as namely, that part of the steel ball, which first touched the plain, is a little flattened, and consequently a part of the force is returned into the ball, and so lost. Next, there is a yielding in the plate itself, and the ears of it; every of which yieldings seem to take off from the force of the body, that it cannot work the effect so accurately, as it would, were those removed.

Next in this contrivance there is, besides the counterpoise of weights, a great deal of massy heavy body; namely, the double beam, and the plate and scale; all which, or at least the greatest part of it, must be moved; and that with a very quick and



INSTRUMENT FOR MEASURING THE FORCE OF FALLING BODIES.

Hooke's original sketch for this instrument is bound with the Royal Society Hooke MS. No. 12.

sudden motion, before the spring (though it be so very thin) can get between the end of the beam and stay, so as to make the effect sensible. Now this quick motion itself does require a considerable strength to effect it, were the counterpoise removed; for such a bulk of body cannot be put into such a quick degree of motion, but by another body, moved with a determinate degree of celerity.

Thirdly, the scales and counterpoise may be all moved, and

yet the small spring not be moved; and though it be so thin, as not to exceed a fortieth or fiftieth part of an inch in thickness, yet is that a space; and the beam may perhaps be moved half that way, and yet the resistance of gravity may make it return before it hath moved the whole space: so that it may be moved a little, and yet not so much as to make it sensible by this contrivance. Nor would the making the spring thinner much mend the matter; since there are other inconveniences, which could not easily be avoided. And that this is more than a mere conjecture, the following experiment will make manifest: for when by my last trial I found the quarter-ounce ball required to be let fall from the height of 36 inches, to move the end of the beam so as to admit the spring, when the counterpoise was 128 times its weight, that I might try, whether the same ball would not move the same counterpoise, though let fall from a much shorter height, I played the spring so, that it was between the beam and the stay, but not so far as it would spring in if it were left free: then letting fall the ball at four inches height, I found, that it had moved the end sufficiently to let the spring slide in as far as it would. I put the spring again in order as before, and let it fall from three inches and an half, and found it there likewise to have moved the beam. I repeated it again at three inches height; but though I tried it several times, I could not find, that it had at all moved the beam.

Now as exact trials of this kind may be very useful in mechanics, so could they be made with bodies perfectly solid, would they be for the establishment of one of the chiefest philosophical principles, namely, to show the strength, which a corpuscle moved has to move another; and though DESCARTES put it as a principle, that *si corpus C plane quiesceret, essetque paulo majus quam B, quacunque cum celeritate B moveretur versus C, nunquam ipsum C moveret, sed ab eo repelleretur in contrariam partem*: yet these experiments do seem to hint, that the least body by an acquired celerity may be able to remove the greatest; though how much of its motion is imparted to the bigger body, and how much of it is recoiled into the smaller, be not determined by these experiments.

Mr. HOOKE was desired to prosecute this experiment with bullets of the same brass metal to several diameters, and to observe the time withal.

Velocity of Falling Bodies.

The lord viscount BROUNCKER was reminded of the experiment formerly recommended to him concerning the first velocity of bodies.

The experiment of the celerity of falling bodies, showing

exactly the time in which they will descend at such and such distances, was ordered to be made by Mr. Hooke.

Eclipse of the Moon.

Mr. Balle, Dr. Pope, and Mr. Hooke were desired to communicate an account of their several observations of the late eclipse of the moon.

Experiments on Air.

Mr. Hooke was ordered to bring in a scheme of experiments concerning air, both such as had been made already on that subject, and those, which should occur to him further to be made concerning it.

The following undated paper appears to belong to this period:

Dr. Hook's *method of making Experiments.* [Derham, p. 26.]

The reason of making experiments is, for the discovery of the method of nature, in its progress and operations.

Whosoever therefore doth rightly make experiments, doth design to enquire into some of these operations; and, in order thereunto, doth consider what circumstances and effects, in that experiment, will be material and instructive in that enquiry, whether for the confirming or destroying of any preconceived notion, or for the limitation and bounding thereof, either to this or that part of the hypothesis, by allowing a greater latitude and extent to one part, and by diminishing or restraining another part within narrower bounds than were at first imagin'd, or hypothetically supposed.

The method therefore of making experiments by the *Royal Society*, I conceive, should be this.

First, to propound the design and aim of the curator in his present enquiry.

Secondly, to make the experiment, or experiments, leisurely, and with care and exactness.

Thirdly, to be diligent, accurate, and curious, in taking notice of, and shewing to the assembly of spectators, such circumstances and effects therein occurring, as are material, or at least, as he conceives such, in order to his theory.

Fourthly, after finishing the experiment, to discourse, argue, defend, and further explain, such circumstances and effects in

the preceding experiments, as may seem dubious or difficult: and to propound what new difficulties and queries do occur, that require other trials and experiments to be made, in order to their clearing and answering: and farther, to raise such axioms and propositions, as are thereby plainly demonstrated and proved.

Fifthly, to register the whole process of the proposal, design, experiment, success, or failure; the objections and objectors, the explanation and explainers, the proposals and propounders of new and farther trials; the theories and axioms, and their authors; and, in a word, the history of every thing and person, that is material and circumstantial in the whole entertainment of the said society; which shall be prepared and made ready, fairly written in a bound book, to be read at the beginning of the sitting of the said society: the next day of their meeting, then to be read over, and further discoursed, augmented or diminished, as the matter shall require, and then to be sign'd by a certain number of the persons present, who have been present, and witnesses of all the said proceedings, who, by subscribing their names, will prove undoubted testimony to posterity of the whole history.

History of the Air.

Feb. 25. Mr. Hooke brought in a scheme of inquiries concerning the air, according to order, which was as follows:

For the making a history sufficient to direct an able inquirer to find out the true nature of the air, there will be requisite,

First, A diligent search after, and a collection of all the observations, as well as all the experiments, that have been made, and are anywhere delivered upon good credit. By which may be had as much of ancient and later observation, as those writers have attested to posterity, about the temperature or nature of the air in several ages of the world, and in several parts of the earth.

Next, A curious and diligent process of making experiments; wherein a most severe inquiry may be made into all particulars, both of the manner of making the experiment, and of the circumstances observable in any of the effects; and every of these trials to be repeated twice or thrice at least, and so recorded and ranged into several orders or degrees; in every of which places they may stand like so many witnesses, to give testimony of this truth, or against that error. And a most severe examination of these witnesses must be made, before a jury can warrantably give their verdict, or a judge pronounce sentence, for branding one

proposition or hypothesis as erroneous and absurd, or for establishing another for a truth or axiom.

Experiments therefore and observations must be made, and those of several kinds, according to the several particulars, that are to be inquired into; and those particulars may, I think, be well enough reduced to three heads, which are these:

First, Of what substance, or of what kind of particles the air consists? Whether infinitely fluid, or definitely solid? If solid, whether the interstice between them be vacuity, or replenished with some more subtile and fluid body? How these particles are formed, or into what shapes they are put, to constitute the body of the air? How generated? from what? by what means? How preserved and continued in that form of air? How, and by what means altered and changed? How it differs from other liquors?

Next, What its quantity or extent is? Whether boundless upward, or terminated? And if bounded, How? Whether with or without a determinate superficies? If with a superficies, Whether it be spherical, elliptical, or irregular? How high that superficies, or the air, is extended above the surface of the earth? Whether it be intercepted in the cavities of the earth, in the substance of water or other liquors, in the pores of animate or inanimate bodies, as plants, woods, stones; in flesh or fish? Whether fish breathe? Whether it be mixed with the blood or humours of the body? or be the material cause of animal spirits? Whether the air circumvest or enclose any of the planets, or other great bodies of the world? as the moon, which many suppose; or the sun, as KEPLER thinks. What its rarefaction or condensation is? By what means effected? What effects it usually does produce, or to the effecting of what it may be made use of? as for weather-glasses, wind-guns, natural perpetual motions, raising water, making springs, &c.

Thirdly, What its qualities or motions are? What its spring or elater is? How caused? Whether from an internal or external efficient? To what bounds it will extend the parts of the air? What strength it has in several degrees? What effects it produceth? Whether it hath gravity? What gravity it hath, compared with other bodies? What is the reason of its gravity? How its gravity is increased or diminished by rarefaction or condensation? and by what degrees? How it comes to rise from the earth? How it sustains the clouds? and what peculiar clouds it sustains at several heights? How it causeth vapours to ascend? How it keeps two flat bodies together? raises and sustains water and quicksilver at a determinate height, in the Torricellian experiment, and pumps? How the gravity of the air keeps some vapours from breaking out of the bodies, in which they are?

What the resistance of the air is to bodies moved through it? How much it retards the descent of heavy bodies? How much it stops the motion of a pendulum? and whether that be the only cause of a pendulum's losing its motion? How it bears up dust, smoke, &c. How it sustains birds? The strength requisite to make a wing, or expanded area, sustain a determinate bulk in the air? And here, what bulk may be raised by what kind of contrivance? As what by that contrivance, which children use to make their paper-kites of? What means may be thought of for raising a man; for raising lights to a considerable height; for conveying intelligence? What contrivance may be made for letting bodies fall from certain heights, for knowing the swiftness of their descent? and what other experiments may be tried this way? How it causes heat or cold? And what is the most natural temperature of the air? What is the temperature of the air in several parts of the earth? and in several parts above the superficies of the earth? To what degree it is rarefied upward, and to what degree it is condensed downward, below the surface of the earth, as in deep wells, in mines? or how much it be at the bottom of the sea, &c. Whether it be the medium, that conveys sound? By what means sound is conveyed, and how fast? Whether a wind will refract a sound? that is, make the sound seem in another place than really it is. How the sound diminishes, according to several distances from the body, that causeth it? How much a fair wind helps the progress of sound, and how much a contrary wind hinders it; and by what means? Whether air conveys light? and if so, How? How it refracts the rays, and by what degrees? What phenomena may be solved by its refraction? Whether it reflect the rays? The causes of its reflective quality? What the degrees of it are, compared with that of other bodies? What phenomena of nature will be solved thereby? What its conformability or applicableness to other bodies is? that is, To what bodies will it readily unite, and to what not? The reason of that property? The several phenomena solvable thereby? What the use of air is in the   of bodies? What the use of it is in respiration, both in men, beasts, birds, insects, fishes, worms, &c.? What its external motions are? Whether the wind be not certain currents of the air? What the causes of those currents or winds are? What the whirlwinds or vortices are, and their causes? What the ebbings and flowings of the air are, and their causes? What the cause of the breeze, and other constant winds? What the celerities of winds are? that is, how far such and such a wind will pass in a minute? The proportion of its strength to its celerity? How much a ship loseth of going as fast as the wind? How much the clouds are moved slower than the ambient air? Whether the air be not moved one way below,

and another above? Whether it be not moved swifter above than below, &c.

Every of which queries hint, as well as need, abundance of experiments to clear them. And though some few of them will need the diligent observation of some travellers (especially such, as refer to the temperature of the air and winds, in several parts of the earth) and cannot well be answered by any observations or experiments here in England; yet I have inserted them, because, as I think an account of such observations will be very necessary for the making an exact history of the air, so I hope, that this honourable society will not want the will, no more than they do the power, to command such observations to be made for the future.

Mr. HOOKE was desired to give in such experiments, as might serve for the resolution of these inquiries, and to begin with those, that relate to the first head, viz. the constitution and substance of the air.

Resistance of Air.

March 4. The following experiments, concerning the resistance of air to bodies moved through it, was brought in by Mr. HOOKE.[1]

For the finding out the resistance of the air to bodies moved through it, it will be necessary, that

Trials should be made with pendulums of all sorts, whose weights should be made with several sorts of materials; as of metal, stone, wood, feathers, wool, &c. and these fashioned into several shapes, as round, elliptical, square, oblong, flat; to be moved flatways, or edgeways, and the like: Then will it be requisite to have one common standard or pendulum, by which the celerity and duration of all the others may be measured.

2. Trials should be made with several of these pendulums; first the exhausted receiver, where being a much less quantity of air, it must necessarily less hinder those motions; and next, in the receiver, where the air is well compressed and condensed, and the differences measured, as before, and recorded: then the effects compared with one another, and with those observed in the free air.

3. Trials should be made with bodies of several substances; and those of several shapes, which should be let fall from several heights, and the times of their several descents to be measured exactly by a pendulum and recorded.

4. Trials should be made by shooting horizontally, from the top of some high tower, or the like, several kinds of bodies; and

[1] These proposals were also printed by Derham, p. 23.

so the time to be accurately observed, that they remain in the air before they touch the ground.

5. Trials should be made, by shooting bodies perpendicularly upward, and observing accurately both the time of their ascent and descent.

6. Trials should be made, by shooting bullets or other bodies horizontally; and so to observe both what time they spend in passing such or such a length; and likewise with what force they hit a mark or body, placed at several distances from the instrument that shoots. These trials likewise should be made with instruments of several strengths.

Mr. HOOKE was appointed curator of these experiments, and to begin with a pendulum sealed up in a glass.

Potter's Cart with Legs.

Mr. AUBREY presented the society with the scheme of a cart, with legs instead of wheels, devised by Mr. FRANCIS POTTER; which was referred to the consideration of Mr. HOOKE, who was ordered to bring in a report of it to the next meeting.

Distillation of Urine.

March 18. Mr. HOOKE suggested, upon this occasion, that urine distilled before it is fermented yields no spirit at all.

Potter's Cart.

Mr. HOOKE's account of the cart with legs, brought in by Mr. AUBREY from Mr. POTTER was read, and ordered, with some alterations, to be sent to the author of this invention.

Mr. HOOKE was also ordered to draw up a full description of this cart, together with a scheme of it, that it might be entered with the animadversions upon it.

More Experiments of Pressure. [Derham, p. 100.]

[These experiments are attributed to HOOKE by DERHAM, pp. 100–6, but though reported, with a few variations by BIRCH, they are given as the work of a Committee of Lord BROUNCKER, Sir R. MORAY, and Mr. BRUCE, and HOOKE's name is not mentioned.]

There was taken a glass tube A B C, (*Fig.* I.) about 23 inches long, and near $\frac{3}{4}$ of an inch over; this was close seal'd up at one end A, and the other end B was drawn into a very small pipe C, and bended according to the shape in the figure. This pipe was found to weigh $1\frac{13}{16}$ ℥+4 gr. or 874 grains, being fill'd with salt water, and the outside wiped dry (which was constantly done in

all the subsequent trials) it weighed $4\frac{7}{16}$ ℥+10 gr. or 2140 grains, whence if we deduct the weight of the pipe 874, we have 1266 grains for the weight of the water that fill'd the pipe. This glass tube being fasten'd to a line, to the end of which was hang'd a plummet of lead, to make it sink; 'twas fitted so as to be let down perpendicularly into the water with the seal'd end A foremost, by which means the small hole of the pipe C was open downwards (that hole being made purposely small, that the air could not get out at it whilst the water got in, nor the water get in whilst the air was passing out.) Then the glass was, for a short

Fig. I.

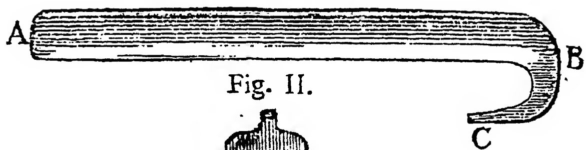
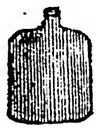


Fig. II.



time, so held in the water, that all of it, except the small bended pipe, was cover'd and inclos'd with the water (which was observ'd in every trial, to the end that the air, within the pipe, might be well cooled) and being let down to the bottom, and there suffer'd to stay for a short space. Afterwards being drawn up, loosened from the line, dried, and exactly weighed; its weight was found $3\frac{13}{16}$ ℥+3 grains or 1833 grains; whence, deducting the weight of the tube 874, we have 959 grains for the weight of the water it brought up. The place was in the Channel to the north of *Quinborough*, the depth of the water 16 fathom and a foot, or 97 foot, where we made the subsequent trials which are rang'd in this table.

Top full	2140 − 874	= 1266	grains
At 97 foot deep − 2	1833 − 874	= 959·307	,,
At 97 foot deep − 2	1832 − 874	= 958·308	,,
At 8 ft. 3 in. − 2 ft.	1060 − 874	= 186·1080	,,
At 16 ft. 6 in. − 2 ft.	1257 − 874	= 383·883	,,
At 33 ft. − 2 ft.	1500 − 874	= 626·640	,,
At 66 ft.	1737 − 874	= 863·403	,,

At 66 ft.	From the Mouth of the tube	1734 − 874 =	860·406 grains
At 33 ,,		1530 − 874 =	656·610 ,,
At $16\frac{1}{2}$,,		1296 − 874 =	422·844 ,,
At $8\frac{1}{4}$,,		1131 − 874 =	257·1009 ,,

A bundle of corks being knit up in a handkerchief, and fasten'd to the line at 33 foot from the small end of the glass, the tube was again let down to the same depth, and the corks, floating upon the water, suspended it at that depth; for, a good while afterwards. Then drawing up the cylinder, by measuring, the cylinder was found to have taken in just as much water, as it had in the last trial, but the weight of the glass was not examin'd. Other trials were made the next day with the same glass cylinder, *viz.* At $8\frac{1}{4}$ foot from the top 1172 − 874 = 298.
Just at high water, the water being at a stand.

At $8\frac{1}{4}$ foot	1131 − 874 = 257	grains
At $16\frac{1}{2}$ foot	1300 − 874 = 426	,,
At 33 foot	1510 − 874 = 636	,,
At $49\frac{1}{2}$ foot	1635 − 874 = 761	,,
At 66 foot	1712 − 874 = 838	,,

The trials did agree, by measure, with some [at the same depth] I had made [early] in the morning.

Another trial was made of the last experiment, because it was done when the water had some current, and the string seem'd to stream a good way from the perpendicular; to prevent which inconvenience, the boat was suffer'd to drive with the current, by which means, the line seem'd to go down perpendicularly into the water. So the cane being pull'd up, after it had staid some time at the depth of 66 foot, it weigh'd 1719 − 874 = 845. At $82\frac{1}{2}$ foot, and left to drive perpendicularly 1883 − 874 = 1009 grains.

Wednesday, March the 11th, in the afternoon, near the same place, where the former trials were made, there were made these following experiments of Compression.

Unto the neck, or mouth, of a common quart glass bottle, was fitted a valve, that opened inwards, and shut outwards; this bottle was so let down into the water, that the mouth went foremost, by which means, the water had, as the bottle was sinking, a free passage into the body of it, to compress the air; but the

shutting of the valve, when the bottle was again drawn up, it was hinder'd from getting out. This bottle, when empty, weigh'd $37\frac{7}{8}$ ounces, and 24 grains, or 18204 grains; filled with salt water, it weighed $78\frac{1}{4}$ ounces and 3 grains, or 37563 grains; whence, taking the weight of the bottle 18204, we have 19359 grains, for the weight of the water, that fill'd the bottle. This bottle being let down $13\frac{1}{2}$ fathoms by the ship's plumbline, or 81 foot, the valve was so hard shut, when it was taken up again, that it was difficult to be thrust open. Though when the small end, or mouth, of the bottle, was set upward, the valve being made of brass, without leather, was found to leak a little, by the hissing noise the air made at it. And when by a knock, the valve was beaten down, the air made a noise in rushing out like that of a bottle of ale when it flies; the bottle, and the water it brought up, weigh'd $65\frac{19}{20}$ ounces, or 31656 grains; whence, deducting the weight of the bottle 18204, we have 13452 grains for the weight of the water. This bottle was again let down to the depth of 14 fathom, or 84 foot; and, being drawn up, was found to weigh, whilst the compress'd air remain'd in it, $65\frac{1}{8}$ ounces, and 19 grains, or 31279 grains; when the air was let out, it lost 21 grains of its former weight, counterpoising only 31258 grains, which was suppos'd to proceed partly from the freeing of the compress'd air, and partly from the loss of a little water, that the violent eruption of the air had blown away; from which last sum, by deducting the weight of the bottle 18204, we have 13054 for the weight of the water.

March the 13th, another experiment was made with another bottle of the same fashion, which empty, weigh'd $37\frac{13}{16}$ ounces and 12 grains, or 18162 grains; fill'd with salt water to the valve, it weigh'd $77\frac{13}{16}$ ounces and 3 grains, or 37353 grains; whence, deducting the weight of the bottle 18162, we have 19191 the weight of the water that fill'd it; this bottle being let down 8 fathom, or 48 foot, the bottle, compress'd air, and water together, weigh'd $60\frac{11}{16}$ ounces and 12 grains, or 29142 grains; the air being let out softly, which requir'd a long time, and the bottle, and water afterwards weigh'd, was found 24 grains lighter, *viz.* 29118 grains; whence, deducting the bottle 18162, we have 10956 grains for the water.

The bottle, with a bended copper pipe at the top, being let

down $8\frac{1}{4}$ foot deep, brought up in it $4\frac{13}{16}$ ounces, and 24 grains of water, the bottle being weigh'd before-hand with a dead weight, or counterpois'd; the same bottle, kept longer at the same depth, brought up $8\frac{9}{13}$ ounces and 25 grains of water; the same bottle, kept yet longer a great deal, brought up $9\frac{7}{16}$ ounces and 6 grains; the water that fill'd the bottle, weigh'd $41\frac{14}{16}$ ounces and 24 grains; which different proportions of water, taken in, we judg'd to proceed, either from the leaking of the vessel at the screw, by which means, the water had a passage into the bottle below the mouth of the bended pipe, which would therefore serve for a vent-hole for the air to get out at; or else that the motion of the top of the water being a little uneven, the pressure upon the bottle must consequently alter, there being sometimes a greater, sometimes a shorter pillar of the water above it; secondly, the bottle itself was, by the cockling of the boat, sometimes lifted higher, then depress'd lower, which did also alter the height of the pressing pillar; whence, as the pressure was a little increas'd, the water got in; and, as it decreas'd, the air got out; and, being held a long while in that posture, many of those changes did very much augment the quantity of water within the glass.

Experiments of the Weight of Water.

A white glass viol, made in the manner describ'd in Figure II. with a smaller short neck, was, by trial, found to weigh, when empty, 1425 grains; when fill'd exactly full with salt water, it weigh'd 5247 grains; whence, deducting the bottle 1425, we have 3822 grains, the weight of the salt water. The same fill'd with fresh water taken out of the *Thames* at *Greenwich*, about low water, weigh'd 5164; whence, deducting 1425, we have 3739, the weight of that fresh water. And weighing afterwards the water, wherewith the strong ale at *Margat* is brew'd, we found it exactly the same with the water taken up at *Greenwich*; whence we conclude, the proportion of these fresh waters, to this salt, to be as 3739 to 3822; that is, near as 45 to 46.

Trials of the Heat and Cold of the Water.

A seal'd thermometer was let down to the bottom of the water, at 16 fathom and a foot, with the great ball upwards, and the stem downward, to the end that, if the cold were extreme, it

might have so far condensed the spirit of wine, as to have admitted the air to have got in out of the neck. And so by pulling it to the top, we might have known the cold at bottom; but though the thermometer was suffer'd to remain a long time at that depth, and were suddenly pull'd up, we could not find that it had any whit more condens'd the spirit of wine, than it was by keeping the same thermometer a pretty while just under the water, at the top, when we judg'd the temperature of this water, both at the top, in the middle, (for, by other trials, we found the same at other depths) and at the bottom, to be all the same.

N.B. *The instrument describ'd in the* Nuntius ad Abyssum, *much better for the purpose than this.* R. W.

Observations of Sound.

Being at a place of the *Thames*, about four miles above *Gravesend*, there happen'd to be shot off several small pieces of ordnance, by a ship that was about half a mile farther up the river; the multitudes of the echoes of each of which shots, made a noise among the several hills, woods, and banks, on both sides of us, just like thunder. And could they have been number'd, they would, questionless, have exceeded an hundred. And having since had the opportunity to observe the noise of thunder, it seem'd to me to be deducible partly from echoes; which would yet seem more probable, if we could, by any experiment, find that the clouds would rebound or echo a sound. A gun being afterwards shot off by the vessel we were in, when we were near the mouth of the *Thames*, and several ships being on this and that side of us, we could very sensibly hear several echoes rebounded from them.

1663

It has been stated that a short time after he entered into the service of the Society, HOOKE drew up a series of Papers entitled, *Proposals for the good of the Royal Society*, which are preserved in the archives. The leading features are:

"The Designe of the Royal Society being the promotion of naturall and usefull knowledge, is good: therefore all things tending to the advancement and perpetuating thereof ought to be promoted. To these ends tends;—such a constitution as will make it self-subsisting.

"All ages afford men enough inclin'd to the study of naturall knowledge. 'Twill be the interest of all such to endeavour to be members of this Society, provided the benefit received be greater than the expense and trouble will purchase elsewhere. Therefore, the benefit of every member thereof in this way, is the soul and life of the Society, and by all means to be advanced. Things tending hereunto are:

"1. That every member of the Society shall have equall freedom to be present at all meetings of it, and shall have free access to their Library, Repository, Instruments, &c., and if absent, shall receive an account of all experiments, observations, discourses, inventions, informations from foreign parts, or correspondencys here at home, querys or proposalls, &c., and whatever other benefit can be afforded them.

"2. That no other person whatsoever, upon any account, shall have any of the aforesaid benefits, before he be, by his earnest desire and the suffrage of the Society, made a Member thereof.

"3. That every Member of the Society shall be equally obliged to promote the ends thereof by paying 52*s*. yearly, and by doing some one duty that shall be charged on them by the Council once a year, or, if his occasions will not permit, to pay 52*s*. more per annum. The dutys may be various, as examining some subject by tryalls or experiments. Giving an account of authours;—giving a history of some trade, manufacture, country, operation, &c.; holding correspondence with some at home, or in foreign parts, about such matters as the Council shall desire, and taking care to provide some experiments for the Meetings.

"4. That these dutys may be more certainly performed, there should be two Secretarys and two Curators at least by office. That the Curators' salarys be but small, and that there be other encouragements given according to desert, upon each new invention, or discovery; either in money, plate, medals, or other gratuitys.

"5. That a certain number of the Society be appointed to manage the prosecution of any new invention, so as to bring it into use, and make it profitable for the Society, and the Inventor."

Several of these propositions were ultimately carried into effect.[1]

Two other papers in HOOKE's handwriting, dated 1663, set forth "The business and design of the Royal Society is—

"To improve the knowledge of naturall things, and all useful Arts, Manufactures, Mechanick practises, Engynes and Inventions by Experiments—(not meddling with Divinity, Metaphysics, Moralls, Politicks, Grammar, Rhetorick, or Logick).

[1] Weld, *History of Royal Society*, pp. 138–40.

"To attempt the recovering of such allowable arts and inventions as are lost.

"To examine all systems, theories, principles, hypotheses, elements, histories, and experiments of things naturall, mathematicall, and mechanicall, invented, recorded, or practised, by any considerable author ancient or modern. In order to the compiling of a complete system of solid philosophy for explicating all phenomena produced by nature or art, and recording a rationall account of the causes of things.

"All to advance the glory of God, the honour of the King, the Royall founder of the Society, the benefit of his Kingdom, and the generall good of mankind.

"In the mean time this Society will not own any hypothesis, system, or doctrine of the principles of naturall philosophy, proposed or mentioned by any philosopher ancient or modern, nor the explication of any phenomena whose recourse must be had to originall causes (as not being explicable by heat, cold, weight, figure, and the like, as effects produced thereby); nor dogmatically define, nor fix axioms of scientificall things, but will question and canvass all opinions, adopting nor adhering to none, till by mature debate and clear arguments, chiefly such as are deduced from legitimate experiments, the truth of such experiments be demonstrated invincibly.

"And till there be a sufficient collection made of experiments, histories, and observations, there are no debates to be held at the weekly meetings of the Society, concerning any hypothesis or principal of philosophy, nor any discourses made for explicating any phenomena, except by speciall appointment of the Society or allowance of the President. But the time of the assembly is to be employed in proposing and making experiments, discoursing of the truth, manner, grounds and use thereof, reading and discoursing upon letters, reports and other papers concerning philosophicall and mechanicall matters, viewing and discoursing of curiosities of nature and art, and doing such other things as the Council or the President shall appoint."

A second document runs thus:

"The designe of the Royal Society being the improvement of naturall knowledge, they pursue that designe by all means they conceive to conduce thereunto; and knowing that much of it lies dispersed here and there amongst learned and experienced men, when it is ofttimes little regarded because not enquired after, and too generally lost by the death or forgettfullness of the possessors, they conceive many usefull and excellent observations may be collected into a general repository, where inquisitive men may be sure to find them safely and carefully preserved, both for the honour of those that communicate them, and to the generall

good of mankind; which is their principall and ultimate aim. And though a virtuous action be a sufficient reward to itself, and that it is ofttimes a greater pleasure to communicate than to concele an invention, yet they resolve to gratify all that communicate with suitable returns of such experiments, observations, and inventions of their own, or advertisements from others of their correspondents, as shall in some kind make them amends. And that you may understand what parts of naturall knowledge they are most inquisitive for at this present, they designe to print a Paper of advertisements once every week, or fortnight at furthest, wherein will be contained the heads or substance of the inquiries they are most solicitous about, together with the progress they have made and the information they have received from other hands, together with a short account of such other philosophicall matters as accidentally occur, and a brief discourse of what is new and considerable in their letters from all parts of the world, and what the learned and inquisitive are doing or have done in physick, mathematicks, mechanicks, opticks, astronomy, medicine, chymistry, anatomy, both abroad and at home;— First, it is earnestly desired that all observations that have been already made of the variation of the magneticall needle in any part of the world, might be communicated, together with all the circumstances remarkable in the making thereof; of the celestiall observations for knowing the true meridian, or by what other means it may be found, the time of making it, by whom and in what manner, with what kind of needle, whether a ship-board or upon land, &c. But from a considerable collection of such observations, Astronomy might be made of that admirable effect of the body of the earth upon a needle toucht by a loadstone, that if it will (as is probable it may) be usefull for the direction of seamen or others for finding the longitude of places, the observations collected together, with the theory thereof, may be published for the generall good of navigation, which they engage to doe soe soon as they have a sufficient number of such observations, wherein mention shall be made of every person soe making and communicating his observations."

Experiments.

March 25. The experiment of purging water from air not succeeding, the engine not being tight, it was ordered to be tried again at the next meeting; and likewise the experiment to be made again, how long a fish will live in water thus freed from air; and the celerity of a falling body in a long glass, exhausted of air. Mr. HOOKE was appointed curator of these three experiments.

Collection of Deep-sea Water.

Sir ROBERT MORAY, Dr. WILKINS, and Mr. HOOKE were

desired to be curators of trying the two sorts of cylindrical vessels for the fetching up of water from the bottom of the sea.

Microscopical Observations.

Mr. HOOKE was solicited to prosecute his microscopical observations, in order to publish them.

Fish and Lime.

A fish was put in a glass with water, closed up with lime, in order to see how long it would live so, the air being excluded from it.

Pneumatical Engine.

April 1. An account was given of the construction of the pneumatical engine, as it then was; which was ordered to be brought in writing, together with a scheme of the engine, by Mr. HOOKE.

Water purged from Air.

Water was purged from air by the said engine, and Mr. HOOKE was appointed to make the experiment of Monsieur HUYGENS of the not subsiding of such water, according to the Torricellian experiment, against the next meeting.

Fish under Diminished Pressure.

The experiment of the exhausting the air from a fish in water was tried in the engine; whereby the fish, which was a tench, was put into much disorder, and buoyed up to the upper part of the water, when he would sink; his eyes also swelling and standing out. The operator was ordered to observe the fish, and how long she would live after the exhausting of the air; the experiment being directed to be tried again at the next meeting, together with that of the celerity of falling bodies in a glass exhausted of air.

Fish and Lime.

An account was given of the tench shut up close with lime in a glass with water, viz. that it had been taken out the next morning, after fourteen or fifteen hours, and found alive. Dr. GODDARD was desired to repeat the experiment, and to fill the glass full of water, and to leave the fish in it a longer time, &c.

Directions for Seamen.

Major HOLMES received a copy of the directions for seamen by the hands of the operator; and Mr. HOOKE was appointed to wait on the said major, and to direct him in the use of the balls and leads for sounding without a line, and of the cylindrical vessel for fetching up of water from the bottom of the sea.

Microscope.

Mr. HOOKE was charged to bring in at every meeting one microscopical observation at least.

Chinese Cart.

Mr. HOOKE'S paper concerning the Chinese cart with one wheel, mentioned by MARTINIUS in his *Atlas Sinensis*, was read, and discoursed upon, that the said cart was like a wheel-barrow: and the paper was ordered to be filed up.

Fish under Diminished Pressure.

April 8. The operator gave an account of a tench tried in the pneumatic engine; that after an hour and an half he opened the glass, whereupon the fish sunk to the bottom immediately, and being taken out was found dead; and upon being opened, its bladder was discovered to be burst. He was directed to give an account of this in writing.

The like experiment was tried upon two young eels, but they seemed not sensible of the exsuction of the air. Order was given for trying these two experiments again at the next meeting.

Moss under Microscope.

Mr. HOOKE showed the company a scheme of the appearance of common moss in a microscope. He was desired to continue, and against next meeting to have ready, the microscopical appearance of the little fishes in vinegar.

Experiments ordered.

Mr. HOOKE was ordered to prepare, for the next meeting, the two experiments of water purged from air; and of the descent of bodies in an exhausted receiver.

Fish.

April 15. The operator was directed to have ready, against the next meeting, several sorts of fishes, to be tried again in the pneumatical engine: And

To put up some fry of fish in a glass with water luted up, and to see how they would thrive there.

It was mentioned by him, that clay put into the water, after the pumping out of the air, revived the carp therein.

Demonstration of Cellular Structure of Cork, Stone, and Bark.

Mr. HOOKE showed two microscopical schemes, one representing the pores of cork, cut both transverse and perpendicular; the other a Kettering-stone, appearing to be composed of globules, and these hollow ones, each having three coats sticking to one another, and so making up one entire firm stone.

He was desired to examine the barks of other trees, and to write down all that he should observe about these and the like appearances; and also to bring in to the next meeting the representation of the little fishes swimming in vinegar.

Jupiter's Satellites.

Mr. HOOKE was appointed to continue the observations of the satellites of Jupiter, as he had opportunities.

Zodiac Survey.

Sir ROBERT MORAY moved that a survey might be made of the stars of the Zodiac by the best telescopes for the discovery of new stars and for rectifying the places of stars already known: for which purpose Sir ROBERT offered himself to take his share, Mr. BALLE undertook the survey of a whole sign; and Mr. HOOKE of as much as he could.

Experiments.

Mr. HOOKE was ordered not to fail of bringing in, at the next meeting, a list of experiments to be made in the new engine for the condensation of the air.

Leeches in Vinegar, and Blue Mold.

April 22. Mr. HOOKE brought in two microscopical observations, one of leeches in vinegar; the other of a bluish mould upon a mouldy piece of leather.

Fish.

Mr. LONG proposed, that fishes of several kinds and several ages might be put into the pneumatical engine, to see which of them would die soonest; he being persuaded, that the youngest would die soonest, and that roach, dace, and carp, would die sooner than tench, eels, &c. The operator was ordered to provide several sorts of fishes, and a more capacious glass, against the next meeting.

Jupiter's Satellites.

The observations made by Mr. ROOKE of the satellites of Jupiter were said to be delivered by the bishop of EXETER to Dr. POPE, who was desired, with Mr. HOOKE, to continue them as they should have opportunity.

Zodiac Survey.

The lord viscount BROUNCKER, Sir ROBERT MORAY, Mr. BALLE, Dr. WREN, Dr. POPE, Dr. CROONE, and Mr. HOOKE, were desired to name, at the next meeting, some sign, or part of a sign, of the zodiac, which they would undertake to survey.

Water purged from Air.

The experiment of the not subsiding of water purged from air was ordered to be made at the next meeting: as also that of making the air extracted out of water return to water.

Two Curators of Experiments.

On this day the second Charter granted by Charles II to the Royal Society passed the Great Seal. It recommended that there should be two or more Curators of Experiments.

Mine of Diamonds and Eyes of Spider.

April 29. Mr. HOOKE produced two microscopical observations, one of a mine of diamonds usual in flints; the other a spider appearing to have six eyes: but this latter was not yet perfectly drawn.

Incubator.

Dr. WREN was desired to acquaint Mr. HOOKE with the apparatus and progress, which he had made in the experiment of hatching eggs by the equal and moderate heat of a lamp, in order to prosecute the experiment, which was said to have been so far advanced, as that thereby blood was produced in eggs.

Zodiac Survey.

In the survey of the zodiac Mr. HOOKE assigned to himself Taurus.

Gnats.

May 6. Mr. HOOKE exhibited a microscopical observation of a female gnat, distinguished from the male by the bigness of her belly; that of the male being thin and lank, the male having also a tuft.

Incubator.

He being asked, whether he had received from Dr. WREN an account of the way of hatching eggs by a lamp, answered, that he had received it in good part; and that the doctor had promised to communicate the rest to him.

Compression of Air.

Mr. HOOKE was ordered to bring in some experiments upon every head of those queries, which he brought in writing at this meeting, concerning the condensation of air, in order to make them in the compressing engine. The said queries were ordered to be entered, and were as follow:[1]

1. To what degree the air may by this means be condensed?

[1] Cf. R. S. MS. 16.

2. What strength is requisite to condense it into several degrees?

3. What bodies will suffer a condensation? as what liquors, whether water, quicksilver, oil, spirit of wine, &c. What solid bodies? as metals, glass, stones, &c.

4. With what force it will be able to shoot a solid body? as a bullet; or a fluid? as water, &c.

5. What bodies the air, or other liquors may be forced into or through? as whether through lead, tin, iron, brass, box, ivory, &c. Whether the air may be forced into liquors? as water, wine, &c.

6. How much heavier the condensed air will be; or how much the weight of a light bulky body will be altered? as whether it may be made heavy enough to make a feather, the pith of elder, cork, or the like, swim or float at the top of the air.

7. Whether some fluid bodies will not grow solid and fixed, whilst they remain under a pressure?

8. Whether the congruity and incongruity of some bodies will not be changed? that is, whether some liquors, that were before congruous and mixed, will not prove incongruous and separate from each other? and the contrary.

9. Whether there will be any variation in the rising of liquors in small pipes? and whether filtration would be hindered or promoted?

10. What variation there will be found in the refraction of the rays of light?

11. Whether the air may not grow thicker? that is more opacous.

12. What variation there will be found, as to heat and cold?

13. Whether fire will last much longer, or be sooner extinguished?

14. Whether the smoke will at all descend, or not rather float at the top like a cloud?

15. What hindrance bodies will suffer in their motions through it? as how much slower a pendulum will vibrate, &c.

16. What animals will live in it, and what die?

How those that live endure it? whether pleasantly or with regret: if it seem painful to them and offensive? whether it make them nimble and acute, or dull and sleepy, &c.

Whether fishes will live in water under a pressure? what they are, and how they endure it?

Whether with pressure they will grow heavy and sink to the

bottom of the vessel? whether several bodies, that will swim in water in open air, will not sink by the increase of pressure?

Carp in Air-free Water.

May 13. Mr. Hooke made two experiments, one of a carp, included in a vessel of water, out of which the air was exhausted; the other, of extracting the air out of water; which air, after some time, will return into water again. He was ordered to bring in an account of the success of these experiments in writing.[1]

[On May 20, Robert Hooke was included in a list of persons to be received, admitted, and ordered to be registered Fellows of the Royal Society.]

Contraction Sounds, &c.

May 20. Mr. Waller related, that in an iron candlestick, such as wax-candle is wound upon, after the candle was burnt down to that part, which clasps it in, and had heated it, there was heard about that part a noise like that of a death-watch, continuing for a while, and then ceasing; and that putting his finger upon it, when somewhat cooled, he found the iron beat like a pulse.

Mr. Hooke added, that blowing a glass ball with a lamp, after it was come to a certain degree of heat, he had heard a sound in it like that, which is made in the experiment of drawing a wet finger about the lip of the glass with water, which there by that pressure is made to frisk. He observed further, that the glass being all red-hot, the noise ceased; but returning, in the cooling, to the former degree, was heard again till it became cold, and so ceased.

Head of Ant, Fly like a Gnat, and Point of Needle.

Mr. Hooke produced three microscopical observations: 1. Of the head of an ant: 2. Of a strange fly like a gnat: 3. Of the point of a needle.

Petrified Wood.

Dr. Goddard produced a curious piece of petrified wood, which was given to Mr. Hooke to have it cut even, in order to see, whether it would polish.

Carp under Diminished Pressure.

Mr. Hooke brought in likewise the following account of what happened to a carp included in a vessel of water, out of which the air was pretty well exhausted.

A middle-sized carp was put into a vessel of water, which was

[1] Cf. R. S. MS. 16, 17.

afterwards closed up and pretty well evacuated of air: this carp, all the time the air was exhausting, was observed to float at the top of the water; and though by struggling it endeavoured to get to the bottom of it, yet it no sooner ceased that endeavouring, but it was buoyed up to the top. After the vessel was pretty well emptied, the air was readmitted, and thereupon the carp sunk down to the bottom of the vessel like a stone, not at all moving its body, but only breathing the water (if I may so call that action, by which fishes take in the water at their mouths, and force it out at their gills) then being taken out of the vessel, it was very dexterously and carefully opened by Dr. CLARKE, who found, that the bladder was manifestly broken in two places.

Spiders in Sage Leaves.

May 27. Mr. HOOKE was charged to look upon sage with a microscope, and to observe, whether there lurked any little spiders in the cavities of the leaves, that might make them noxious.

Structure of Petrified Wood.

Mr. HOOKE produced Dr. GODDARD's petrified wood, being cut smooth, and having a polish; which being viewed by him in a microscope in its closest part, still appeared porous. He was desired to cause the same stony wood to be cut sideways; and also to bring in his observations upon it.

Male Gnat. Air-free Water.

Mr. HOOKE brought in his microscopical observation of a male gnat. He was ordered to bring in writing the experiment of air exhausted out of water, and relapsing into it again.

Robert Hooke, F.R.S.

June 3. Mr. HOOKE was elected a Fellow of the Society by the council, and exempted from all charges.

Condensing Engine.

At a meeting of the Society on the same day, the experiment of raising water in a kind of small weather-glass, by the pressing in of air in the condensing engine, was tried; but by reason of the engine's leaking, proved imperfect, and was therefore ordered to be repeated at the next meeting.[1]

Petrified Wood.

Mr. HOOKE was ordered to bring in writing his observations upon Dr. GODDARD's petrified wood at the next meeting: And

[1] See an account of the proceedings of this meeting in Mr. HOOKE's letter to Mr. BOYLE from London, June 5, 1663, reprinted below from Mr. BOYLE's *Works*, vol. v, p. 530.

Sage Leaves.

To observe by a microscope, whether there be any cavities in sage-leaves for little spiders to lodge in.

June 5.

LETTER FROM HOOKE TO BOYLE.

London, June 5, 1663.

Ever honoured Sir,

I have put up and sent the things you gave order for, together with four pair of gloves Mr. WHIT. spoke for; and should have come away my self, but that having received a particular favour from the Society, and also an extraordinary injunction to see the condensing engine in a little order against the next Wednesday, I did hope you would be pleased to dispense with my absence from attending on you for two or three days longer, till the next Wednesday be past, and that because those extraordinary days being holidays, you may perhaps have other avocations, especially being but newly come thither. For I remember you were pleased to say, that you thought it would be a week before the ceremony of visits would suffer you to settle about any business, and so should have little use of me till then; and if your occasions would permit a dispensation for my stay here any longer time, I should endeavour to improve the time the best way I am able to serve you. But, Sir, I make it no further my desire, than the convenience of your affairs permit, having wholly resigned myself to your disposal. Nor should I have presumed to have trespassed your commands thus far, had I not thought, that the Society might have taken it a little amiss, if, at the very next meeting, after so great an honour done me, I should be absent. There was nothing of experiment, but only a trial of the condensing engine, which only held enough to shew us, that it would not hold long enough with that kind of cement we used; for after the air was condensed into about half its dimensions, it forced its way through the cement of the covers, though laid very thick in the joints. But I think that inconvenience will be easily remedied against the next day. Dr. BATES, I understand, was chosen by the council a member of the Society, who thereupon returned a great compliment, together with a present of ten pounds in new coined silver. There happened an excellent good discourse about petre-

faction; upon which occasion several instances were given about the growing of stones: some, that were included in glass viols; others, that lay upon the pasture ground; others, that lay in gravel walks; which was known by putting a stone in at the mouth of a glass viol, through which, after a little time, it would by no means pass. Next, the story of a field's being filled with stones every third year, was confirmed by some instances. And that the stones in gravel walks grow greater, had been often proved by sifting those walks over again, which had formerly passed all through the sieve, and finding abundance of stones too big to pass through the second time. Upon this, mention was made of the production of stones or lapidious concretions in the bodies of animals, and abundance of very strange instances were alledged of the finding of stones in several parts of a man's body, as in the joints of his fingers and toes, and of other parts of his body; and it was generally agreed to by all, that those people, that drink petrifying waters, are extremely subject to the stone. A place was mentioned in *Oxfordshire*, where there is such a water, and the people round about are extremely plagued with that disease. Mr. PELL and some others mentioned to have read somewhere an observation, that there were more such concretions taken from one man, than the weight of his whole body amounted to.

Mr. PALMER related a story of a French physician (whose name I have forgot) who landing sick at *Dover*, and taking a glister, voided an incredible number of small and great cockle-shells. The matter of fact was confirmed by very many of the Society, who had either had very good relation of it, or seen some of the shells. Dr. CHARLTON added, that they had lain a good while upon sea, and fed upon nothing but cheese (made of the milk of goats, which fed upon the mountains of *Bononia*, which are very full of such shells) and brandy. Monsieur MONCONIS related a story of a woman in France, who for a long time together every month voided the perfect bones of children *instar menstruarum purgationum*, and has promised to send over some of those bones. Another very strange story he related of a woman, who, being opened, was found to have a child petrified in a certain bag or appendix distinct from the uterus. Upon this several instances

were added by many of the Society, about conceptions *extra uterum*. Dr. CLARK told of a woman in *London*, who had carried a child eighteen years in her belly, and that she had in the mean space several children, one whereof he said was eleven years old, when, by an impostume on the side of her belly, all the bones of the child came from thence. There were several of the Society, who had seen the bones, and talked with the woman, and Dr. CLARK named the physician, who extracted those bones. Collonel LONG added, that a very noble lady, now alive, had told him, that a child remaining in her a good while, she knew not how, she was afterwards delivered of it *per sedem*, and added, that he had seen the bones. Dr. CHARLTON upon this mentioned DENSINGIUS's little book about a petrified child found in the abdomen. To which Dr. CLARK added, that the book was lately reprinted with the opinion of several learned men, most of which judge it a fiction, from several contradictions it contains. Dr. CLARK likewise told a very odd story, which the duke of ALBEMARLE told him, of one of his officers, who was grievously tormented with the stone in his kidnies, of which he was perfectly cured merely by chewing tobacco; and that the duke commends it to the world, as an excellent remedy for most kind of diseases. Sir ROBERT MORAY brought in a petition, that was presented to his majesty, wherein the petitioners desired a patent for an invention of meliorating all kinds of grounds, so as to make the worst to bear any kind of grain; and for another of making all kinds of fruits and flowers better, and the bearing plants more fruitful. Much was argued for and against the steeping of corn, and several ways were mentioned, by which it had been done, and with what successes. It was generally concluded to preserve corn from smut; several other ways were hinted of preserving corn from smut. Mr. HENSHAW mentioned a way of shaking off the mildew from the ears of corn, by a rope drawn over the tops of them by two men at either end of it; which mildew was found to make the corn hide-bound. Mr. LONG told of a strange increase, that was received from corn sown in bad ground with the husks on. Mr. PARKER affirmed, that there was a gentleman in *Sussex*, that had a way of chusing the ears of corn, whilst in the blow, for his seed wheat, which is so excellent, that he will be bound

to forfeit a great matter, if any of his seed corn yield smut, though sown in the same ground several years. Mr. LONG related the improving of many thousands of acres of land, from sixpence an acre to fifty shillings, by means of conveying water to overflow it. The drying and singeing, and ripening of corn was mentioned, as likewise the way of preserving corn in the husk for very many years. Several other observable particulars were mentioned. But they would be too long to trouble you with, you having already received too much by this long scribble from,

Honoured Sir,

your honour's most affectionate,
most faithful and most
humble servant,
RO. HOOKE.

I have here inclosed a letter I received from the amanuensis of the Society.

Dr. KUFFLER's wife has been here to enquire of me about an engine for distilling water, of which I told her I would acquaint you, when I next wrote.

Sir, my lord BR[OUNCKER] and Sir R. M[ORAY] present their humble service to you. And Sir R. M. says, he has a quarrel with you, because you would not let him see you, before your leaving the town.

I have not been able to meet with doctor SYDENHAM all this morning, and so cannot send any of the sage, for there was none left at my lady's house.

Condensing Engine.

June 10. The experiment of killing a mouse in the condensing engine succeeded not, because the vessel was not staunch; and it was ordered to be tried again at the next meeting; and that the engine be put into better order.

Sage Leaves.

Mr. HOOKE gave an account of his having looked upon sage-leaves with a microscope, to see whether in the cavities thereof any little spiders lurk; and he said that he had seen none.

Petrified Wood.

Mr. HOOKE's observations upon Dr. GODDARD's piece of petrified wood were appointed to be read at the next meeting.

Sinking and Floating of Wheat.

The operator was directed to give in writing what he had observed in the experiment of the sinking and floating of wheat.

Petrified Wood.

June 17. Mr. HOOKE's observations upon Dr. GODDARD's piece of petrified wood were read, and ordered to be registered, as follow:

It resembled wood, in that,

First, All the parts of the petrified substance seemed not at all dislocated or altered from their natural position, whilst they were wood; but the whole piece retained the exact shape of wood, having many of the conspicuous pores of wood still remaining pores, and having a manifest difference, visible enough between the grain of the wood and that of the bark; especially when any side of it was cut smooth and polished, for then it appeared to have a very lovely grain, like the grain of some curious close wood.

Next it resembled wood, in that all the smaller and (if I may so call those which are only to be seen by a good glass) microscopical pores of it appear (both when the substance is cut and polished transversely and parallel to those pores) perfectly like the microscopical pores of several kinds of wood, retaining both the shape and position of such pores.

It was differing from wood,

First, In weight; being to common water as $3\frac{1}{4}$ to 1: whereas there are but few of our English woods, that, when dry, are found to be as heavy as water.

Secondly, In hardness; being very near as hard as flint, and in some places of it also resembling the grain of a flint. It would very readily cut grass; and would not without difficulty, especially in some parts of it, be scratched by a black hard flint. It would very readily strike fire against a steel, and also against a flint.

Thirdly, In the closeness of it; for though all the microscopical pores of the wood were very conspicuous in one position, yet by altering that position of the polished surface to the light, it also was manifest, that those pores appeared darker than the rest of the body, only because they were filled up with a more dark and dusky substance, and not because they were hollow.

Fourthly, In that it would not burn in the fire; nay, though I kept it a good while red-hot in the flame of a lamp, very intensely cast on it by a blast through a small pipe, yet it seemed not at all to have diminished its extension; but only I found it to have changed its colour, and to have put on a more dark and dusky brown hue: nor could I perceive, that those parts, which seemed to have been wood at first, were anything wasted, but the parts

appeared as solid and close as before. It was further observable also, that as it did not consume like wood, so neither did it crack and fly like a flint, or such-like hard stone. Nor was it long before it appeared red-hot.

Fifthly, In its dissolubleness; for putting some drops of distilled vinegar upon the stone, I found it presently to yield very many bubbles, just like those which may be observed in spirit of vinegar, when it corrodes coral. Though I guess, many of those bubbles proceeded from the small parcels of air, which were driven out of the pores of this petrified substance, by the insinuating liquid menstruum.

Sixthly, In its rigidness and friability; being not at all flexible, but brittle, like a flint; insomuch, that with a knock of a hammer I broke off a small piece of it, and with the same hammer quickly beat it to a pretty fine powder upon an anvil.

Seventhly, It seemed also very differing from wood to the touch; feeling more cold than wood usually does, and much like other close stones and minerals.

The reason of all which phenomena seems to be this:

That this petrified wood having lain in some place, where it was well soaked with petrifying water (that is, such a water, as is well impregnated with stony and earthy particles) did by degrees separate, by straining and filtration, or perhaps by precipitation, cohesion, or coagulation, abundance of stony particles from that permeating water; which stony particles, having by means of the fluid vehicle, conveyed themselves not only into the microscopical pores, and perfectly stopped up them, but also into the pores, which may perhaps be even in that part of the wood, which through the microscope appears most solid, do thereby so augment the weight of the wood, as to make it above three times heavier than water, and perhaps six times as heavy as it was when wood. Next, they hereby so lock up and fetter the parts of the wood, that the fire cannot easily make them fly away; but the action of the fire upon them is only able to char those parts, as it were, like as a piece of wood, if it be closed very fast up in clay, and kept a good while red-hot in the fire, will by the heat of the fire be charred and not consumed; which may perhaps be the reason, why the petrified substance appeared of a blackish-brown colour after it had been burnt. By this intrusion of the petrified particles it also becomes hard and friable; for the smaller pores of the wood being perfectly stuffed up with these stony particles, the particles of the wood have few or no pores, in which they can reside; and consequently no flexion or yielding can be caused in such a substance. The remaining particles likewise of the wood among the strong particles may keep them cracking and flying as they do in a flint.

Sage Leaves.

Mr. Hooke was desired to continue his observations by a microscope upon sage-leaves, he having at some times seen nothing like little spiders in the cavities thereof; and at other times abundance of little eggs upon the said leaves.

Sinking and Floating of Wheat.

Mr. Hooke's account of the wheat sinking and floating again in water, was read, and ordered to be registered.

Microscopical Observations.

June 24. Dr. Power produced several microscopical observations made by himself: and Dr. Wilkins, Dr. Wren, and Mr. Hooke were appointed to join together for more observations of the like nature.

Viper-powder.

The pot of viper-powder, kept by Mr. Pulleyn, was opened; but nothing alive was found in it. Mr. Hooke was desired to look upon some of the powder through a microscope, Mr. Pell relating, that Sir Charles Cavendish had kept a box of viper-powder, which being opened and found extremely stinking, had store of little moving creatures in it, like mites of cheese.

Experiments for Charles II.

July 1. It was ordered, that the council meet on the Monday following, about three of the clock, to consider of experiments proper for his majesty's reception: and that Col. Long, Dr. Christopher Wren, and Mr. Hooke, be desired to meet with them upon this occasion.

Air in Water.

Mr. Hooke's experiment for finding, whether the bubbles, that rise out of the water upon the emptying a receiver of the air, are real air, or only rarefied parts of water, was ordered to be repeated at the next meeting.

Incubator.

Dr. Wren was put in mind to communicate to Mr. Hooke his method of hatching chickens by a lamp.

Viper-powder and Sage Leaves.

Mr. Hooke gave an account, that he had looked with a microscope upon the viper-powder kept by Mr. Pulleyn, but found

nothing alive. He was ordered to continue his observations upon sage-leaves.

Microscopical Appearance of Blood.

Dr. WILKINS mentioned, that Dr. CROUNE had, in the blood of a dog dissected by him, found abundance of little insects. Mr. HOOKE was desired to take notice thereof, and to make frequent observations with a microscope on the blood of several animals.

July 3.

LETTER FROM HOOKE TO BOYLE.

Friday 10 in the morning, from *Pall-Mall,*
[July 3, 1663.]

Honoured Sir,

I have not received any of your commands since I took my leave of you for *London.* I know not, whether there has any thing miscarried, nor have I written any thing since this day sev'night, there having happened little or nothing considerable in that time; only I should have sooner given you an account of an interview I had of Mr. HOBBES, which was at Mr. REEVE's, he coming along with my lord DE. to be assistant in the choosing a glass. I was, I confess, a little surprised at first to see an old man so view me and survey me every way, without saying any thing to me; but I quickly shaked off that surprizal, when I heard my lord call him Mr. H. supposing he had been informed, to whom I belonged. I soon found by staying that little while he was there, that the character I had formerly received of him was very significant. I found him to lard and seal every asseveration with a round oath, to undervalue all other men's opinions and judgments, to defend to the utmost what he asserted though never so absurd, to have a high conceit of his own abilities and performances, though never so absurd and pitiful, *&c.* He would not be persuaded, but that a common spectacle-glass was as good an eye-glass for a thirty six foot glass as the best in the world, and pretended to see better than all the rest, by holding his spectacle in his hand, which shook as fast one way as his head did the other; which I confess made me bite my tongue. But indeed Mr. PELL's description of his deportment, when discoursed with about mathematical demonstrations (which he gave the last Wednesday)

surpasses all the rest. There was very little done this week at *Gresham* college, the whole stay being not much above an hour.[1] My lord B. Sir R. M. and Monsieur ZUL. were very inquisitive when you would return. There was an account read of Monsieur LE FEVRE's trial to volatilize salt of tartar with burnt alum, which you have long since heard. Monsieur ZUL. tried his own experiment, but it succeeded not, though he confessed the engine was very tight, and it will be tried again the next day according to his ordering. The accounts, which I acquainted you with the last week, were not brought in as was expected. Sir R. M. gave in the measure of an infant of sixteen weeks old, which was sent him out of Scotland, a pattern whereof I have here enclosed. There is a meeting of the council upon Monday, where your presence is much expected and longed for. There is very little in Dr. POWER's microscopical observations but what you have since observed; only there is a pretty experiment he tried with the leeches in vinegar, that survived the freezing of the vineger they lived in; and another pretty experiment he has in his philosophical reflections upon his observations, which is of making a certain kind of coals kindle into a fire and flame, by throwing water on them, when newly dug out of the mine. I am sorry to see, that he intends to publish several experiments about colours, which I am confident might be originally yours. He will likewise publish the experiment of freezing an eye, to find the shape of it, whose invention he ascribes to another. There is not much more besides, that is very considerable in it, and therefore I shall refer the further account of it till your return, till when I shall keep the book by me. I have made a microscope object glass so small, that I was fain to use a magnifying glass to look upon it, but it did not succeed so well as I hoped; but I suppose it might be, because this being the first I had made, the tool was not very true, nor my hand well habituated to such an employment. And therefore I despair not of better success in my next attempt. Mr. LOWER was to have waited on you, and was sorry to miss you here in town. He had Dr. WILLIS's service to have presented to you, whose book he tells me is within a little while to come forth, and he added, that Dr. WREN had drawn the

[1] July 1.

pictures very curiously for it; and I am glad to hear it will afford such considerable discoveries, which I doubt not but you know. I question not, but that Mr. OLDENBURG has acquainted you with the news, that is extant, in this enclosed, and therefore I shall not trouble you with that particular. Nor has there occurred any thing else since my coming worth your knowledge; otherwise it should have been sent you by,

Honoured Sir,

your most affectionate,

most faithful, and

most humble servant,

ROB. HOOKE.

I suppose Mr. MURRAY has told you, that Mr. NICOLLS desires to speak with you.

I just now received a letter from Mr. WHIT. to send down the horse; but it is so lame, that it is altogether unable to perform a journey.

Experiments for Charles II.

July 6. There met with the council, according to the order of the preceding meeting, Col. LONG, Dr. CHRISTOPHER WREN, and Mr. HOOKE.

The king's entertainment being taken into consideration (for which the meeting of the council on this day was appointed) it was ordered,

That Mr. HOOKE and the operator take care so to prepare the compressing engine, that it might not fail in the trying of experiments therein: And

That the operator take care to have the long tubes set up against the Monday following.

Mr. HOOKE was charged to show his microscopical observations in a handsome book to be provided by him for that purpose: to weigh the air, both in the engine and abroad: to break empty glass balls; as also to let the water ascend into them after they have been emptied: to provide the instrument for finding the different pressure of the atmosphere in the same place, as likewise the hygroscope made of the beard of a wild oat.

Edge of Razor, Taffeta, and Millepede.

July 8. Mr. HOOKE brought in three microscopical observa-

tions, 1. Of the edge of a razor: 2. Of a piece of fine taffeta-ribbon: 3. Of one of the millepedes.

Air in Water.

He was ordered to give, in writing, the two experiments lately made concerning the bubbles remaining on the top of the water in glass balls, upon the emptying of the receiver; and the not subsiding of the water freed from air.

LETTER FROM HOOKE TO BOYLE.

[*c.* 10 July 1663.]

Right Honourable,

I did expect and hope, that you would have been in *London* before this; nor are your friends at *Gresham* college less sollicitous after your return; I being asked by every one almost, when you would be here. There was but little done this last Wednesday,[1] because of some papers which were read, which took up almost all the time. The one was sent in from Sir PAUL NEILE, being an account of his way of making, ordering and bottling of cyder, and his judgment of the cause of the fermentation of it, *&c.* wherein indeed were very many new observables, though several of them were contradicted by Mr. WALLER and some others, Sir P. being very much against the fermenting of cyder very much; and Mr. WALLER and some others of the contrary opinion. There was likewise read a relation sent from the coast of *Coromandell* in the *East-Indies*, by a person of credit, and one, who had lived a governor there above eleven years. The sum was this, that for three or four months, in the summer time, the wind did all day, from eight in the morning to four in the afternoon, blow so extremely hot from the land, that the people are hardly able to endure it, but are fain to sit in tubs of cold water, up to the neck, to preserve themselves from being stifled; that every night the wind blows directly contrary, namely, from the sea, with as great an excess of cold. But this is not so strange, because it happens in several other parts of the world; but what he added further is sufficiently strange to an European, *viz.* that their way to preserve their drink cold in this extremity of heat, was to put it up in their earthen vessels (what form they are of I know not) and expose the bottle, hung by a stake, or the branch of a tree,

[1] July 8.

to the scorching sun and suffocating winds; for by that means they find the contained liquor, at four in the afternoon, excessively cold, and extremely pleasant and refreshing; nor would the relator himself, nor any that he had heard of, venture to give a reason for it. We made a trial of monsieur ZULICHEM's experiment, where indeed it succeeded so far, that with the pumping, that was used about it, the water would not descend, though I am very confident, if the pump had been longer plied, the event would have been much otherwise; and we shall this next week try with a pipe of five or six foot long, whether it will remain suspended or not. We have lately likewise tried two other experiments: the one was, there were two bolt-heads full of water inverted into restagnating water, out of which, when the air was extracted, there remained in each a small bubble at the top: into the place of one of the bubbles of extracted air as much common air was put, and then both of them set aside and observed. The event was, that both the bubbles vanished into the water, but that of the common air remained longest. Since that, we exhausted the air out of one of those bolt-heads, and put common air in the place of it; then the other was filled with common water, and a bubble of air, equal to that in the other, was put into it, and it was found, that the air was vanished into the exhausted water, but that the other remained almost intire in bulk. I am taking order about the engraving of my microscopical pittance, which I hope will be very well done. I this week observed a creature newly come out of the egg, which by comparing it with the biggest old one I have seen of that kind, I found to be above 130000 times less than the bulk it was likely to come to, if it survived; of which, I believe, we shall not find many other examples in nature. I have now procured the new Jamaica nuts; and had I not been advertised, that your return would be either this Saturday, or the following Monday, they had been sent you by,

Right honourable,
your honour's
most affectionate
most faithful and
most humble servant,
ROB. HOOKE.

I have sent a small bag of the nuts, understanding by Mr. WH.'s letter, that you will not be here till Thursday. The two foot perspective I also sent, the box was delivered to the carrier the last week before he went away. Mrs. KUFFLER is very earnest to know, when you will give order about the engine, and seems to be a little angry, and wonders you should be worse than your word, and such kind of speeches; though I had given her the reason, why you could not do it before you went hence.

Air in Water.

July 16. Mr. HOOKE brought in an account in writing of two experiments tried by the society, one concerning the uniting and mixing of air and water; the other concerning the suspension of defecated water in a bolt-head after the receiver had been well

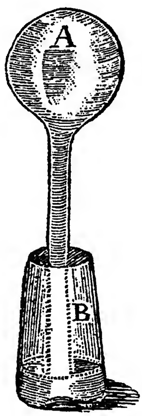


ILLUSTRATION TO HOOKE'S ORIGINAL MS. 'OF THE UNITING AND MIXING OF AIR AND WATER'.

Royal Society Hooke MS. No. 20, dated 1 July 1663.

exhausted. This account was ordered to be registered, and was as follows:

A bolt-head, of the shape of A, containing about six or seven ounces of water, with a neck about six inches long, was filled top-full with water, and the mouth of it inserted into a small glass body of water as B, and so conveyed into the receiver of the evacuating engine, and kept there till the receiver had been very well exhausted. Then it was taken out, and the little bubble of air, that was found in the bolt-head, and had been drawn out of the water, was removed, and as much of the common air put

in its place, and then suffered to stand in the posture represented in the figure. By this, at the same time, was set just such another bolt-head and body, and was filled with common water, out of which the air had not been exhausted; only a bubble of common air, about the bigness of that which was put into the other bolt-head, was left at the top. These being observed afforded these phenomena; the bubble of air in the first was observed to be vanished into the water within a day or two; but the bubble in the latter was found not much diminished about a week after.

A bolt-head and body, just like the former, was, upon Monday July the 16th,[1] set into the receiver, out of which the air was presently drawn; and the bubbles did rise very copiously out of the water into the bolt-head, and beat down all the water out of it, below the surface of the water in the body. These things were suffered to remain in this posture till July the 8th,[1] the receiver being kept all the while well exhausted, by often repeated pumpings: then it was taken out, and the bolt-head was filled top-full with this exhausted water inverted into the body, and again included in the receiver. After the receiver was pretty well exhausted, there arose a small bubble out of the neck of the bolt-head, which getting to the top, and as the pumping was continued, expanding itself, did beat down all the water out of the bolt-head as before. Then the bolt-head was again taken out of the receiver, filled top-full with the exhausted water inverted into the body, and closed into the receiver as before: out of which though the air was pretty well exhausted by pumping about half a quarter of an hour, yet the water was observed to remain suspended in the bolt-head, and not at all to descend.

Prince Rupert's Rotary Pump.

Sir ROBERT MORAY presented the society from Prince RUPERT with a certain water-raising engine, which was ordered to be tried.

Mr. HOOKE, in a letter to Mr. BOYLE written this day, and published in Mr. BOYLE's *Works*, vol. v, p. 532, observes, that such an engine is taken notice of in SCHOTTUS's *Mechanics*, 'whose contrivance is continually to raise water by turning round a cylinder with a sliding board in it, included in another hollow cylinder or barrel'.

Fine Lawn, Gilt-edge of Paper, and Tinea.

Mr. HOOKE produced three microscopical observations. 1. Of fine lawn. 2. Of a very smooth and even gilt-edge of fine Venice-paper. 3. Of a *Tinea argentea.*

[1] There is a discrepancy in the dates.

July 16.

LETTER FROM HOOKE TO BOYLE.

[July 16, 1663.]

I was very sorry to find the coach return from *Leez* without bringing you in it; but I am glad however to hear, that your return will be the beginning of the next week. There was but little done this Wednesday at *Gresham* college, much of the time being taken up in observing the experiment, which was made with the glass tubes of forty five foot high, in which there was little remarkable, but what you will easily predict must necessary follow; that is, that the water, upon the turning off the lower stop-cock, fell down to between thirty two or thirty three foot from the bottom; that as it fell, and a good while after, abundance of bubbles appeared near the top of the water; that as those bubbles rise for a good while, so all that while the water continued to descend a little; insomuch, that when we were coming away, I observed it to be about 29½ foot high, and it is likely it would afterward descend lower. That one of our tubes consisting of several pieces, leaked. That upon these observables, several things are ordered to be tried the next day; as first to fill the tube with exhausted water to * * * the bubbles that rise; to make a device to close the stagnant water so, that the air may not get in: to make the other tube tight, and so to join both together by a bended pipe at the top, and the like. After we returned from this experiment, Sir R. MORAY presented the Society with an engine sent to them by prince RUPERT; being for raising water, such a one as, I am sure, you have seen and taken notice of in SCOTTUS his mechanicks, whose contrivance is, continually to raise water, by turning round a cylinder with a sliding board in it, included in another hollow cylinder or barrel. The engine has not been tried, but it will be the next Wednesday. But I find, that it goes exceeding hard with the several grating and sliding motions, that it has, so that it is more likely to prove a pretty curiosity than a useful engine. But this gave an occasion of producing the definition or description of the marquis of WORCESTER's water-commanding engine, which is so purely romantick, that it would serve one rarely to fill half a dozen pages in the *History of Fortunatus his wishing Cap*. A transcript of some of the most

observable passages, because I could not procure the book itself to send you, I have here enclosed, which if it should chance to perform but the least part of what is therein specified, my lord BRERETON is likely to pay 5*l.* towards the revenue, that is to accrue thereby to the marquis, he having wagered so much against him. I was since my return to *London* to see this engine, where I found CALTROP, his chief engineer, to laugh at it; and as far as I was able to see of it, it seemed one of the perpetual motion fallacies. Of which kind CALTROP himself, and two or three others, that I know, are labouring at this time in vain, to make, but after several ways; and nothing but costly experience will make them desist. We had next Sir R. MORAY and Mr. OLDENBURG's relation of the excellent French lithotomist, which gave occasion to Sir ANTHONY MORGAN to relate the history of an Irish lithotomist that does the same thing, though, if it be according to his description, by a more easy and expedient way. And Dr. WHISTLER affirmed the same to be done by a Scotchman, and calls it cutting by the gripe, the more perfect relations of which are to be given in by those persons in writing. Sir R. MORAY likewise produced the stone cut out of the heart of the Scotch nobleman I formerly told you of; it was very hard, and of a mishapen figure, and looked in colour like a flint. Mr. PELL brought in a bag of sand, which he affirmed would be baked into a substance like Flanders jugs. It looks and feels like clay beat to dust, and I guess it to be a substance between both; that is a sandy clay, or clayish sand. I cannot find any peculiarity in it with a microscope. Dr. CHARLTON gave a description of *Aubery* in *Wiltshire*, which seems indeed by his relation a very strange piece of antiquity, and more admirable than *Stoneheng*, which he hopes to make an argument to confirm his hypothesis about that *Chorea Gigantum*. Dr. POPE is going for *Italy*, but I suppose will not be gone before your return, who will be very glad to be charged with inquiries by you. Some things about the growth of salmons were handed to and fro, some flatly contradicting others. The last thing we had was a relation of Sir W. PETTY's ship new modelled, upon which he has already laid 50*l.* that it shall go safe to *Holy-Head* and back again; and it was set forward on that attempt before he writ that letter, which was read. I have sent

you likewise a new book of philosophy, but I fear it contains but little of that subject worth any thing. I but just now received it, and have not had time to look it over. There is nought else worth your knowledge, only this enclosed, which I suppose contains several things, which should else have been sent you by

Right honourable,
your honour's most affectionate,
most faithful, and most humble servant,
R. HOOK.

Sounding.

July 22. Mr. HOOKE mentioning, that a better way might be suggested to make the experiment [of sounding of depths without a line], was desired to think further upon it, and to bring in an account thereof at the next meeting.

Chertsey Spring.

Mr. HOOKE was ordered to take a journey to Chertsey, at the charge of the Society, and to observe a spring [yielding red oleaginous matter], and to inform himself of all circumstances concerning it, and also to distil some of it.

Insects in Barnet Waters.

Dr. CLARKE related, that the Barnet waters, on a hot sunshiny day, were found full of little insects; which insects, the water being strained, remaining upon the cloth, turn into a jelly. He and Mr. HOOKE were desired to go to Barnet for a more particular account of this matter.

Prince Rupert's Rotary Pump.

Prince RUPERT'S water-raising engine after the method of CAVALLERIUS'S *Hydrocontisterium novum,* was ordered to be tried; and a description of it was given in by Mr. HOOKE, which was ordered to be registered, as follows:

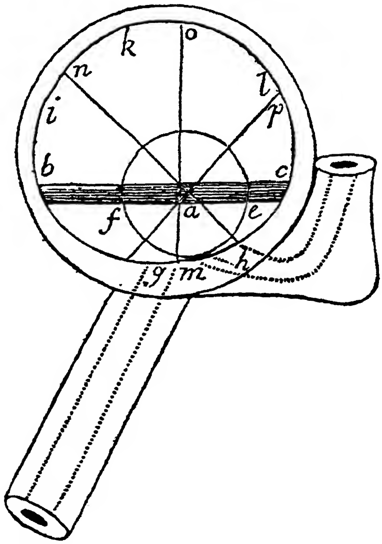
It consists of three parts.

1. A hollow cylinder *i, k, l, h, g,* which cavity is not perfectly round; but of such a figure, that all the diameters drawn through the point *a* (which is out of the middle) are equal.

2. Of a solid smaller cylinder, *e, f, d*; perfectly round, which is so placed with the hollow of the former, that one side of it doth always touch the concave cylinder in the point *m*.

3. Of a sliding valve or board, *b, a, c*; which being equal to the diameter of the figure, always toucheth opposite sides of the concave cylinder; and as the smaller cylinder is moved round within the hollow one, the valve is made to slip to and fro in a

groove or mortise made fit for it, through the middle of the smaller cylinder; both ends of which cylinder passing through adapted holes in the ends of the smaller cylinder, have handles fastened to them, by which the cylinder is turned about from *f*, by *d*, to *e*; by which means the end of the valve *b*, is moved by *n*, *o*, *l*, *c*, &c. By this circumstance of the cylinder and valve, the water is always drawn in by the hole *g*, which is behind the valve; and cast out by the hole *h*, which is before it.



PRINCE RUPERT'S WATER-RAISING ENGINE.
The original sketch is in the Royal Society Hooke MS. No. 21.

Sounding and Water Collecting.

July 29. Mr. HOOKE produced several figures, both for sounding instruments without a line, and for vessels to fetch up water from the bottom of the sea. He was desired to give an explanation of these figures in writing; and the operator was ordered to make two models against the next meeting, one of the sounding instrument, and another of the water-drawing vessel, each after the draught of the first figure of each kind.

Air-pump.

Mr. HOOKE was ordered to apply Mr. BOYLE's engine to the long tube for the Torricellian experiment, to see whether the air could be thence exhausted; and whether, thereupon, the water would subside at all.

Chertsey Spring and Fish Bladder.

Mr. HOOKE was put in mind of going to see the spring near Chertsey; as also, of assisting Dr. CHARLETON, in drawing a scheme of the carp or salmon, which he was to dissect, in order to show the duct from the bladder to the gills of the fish.

Microscope.

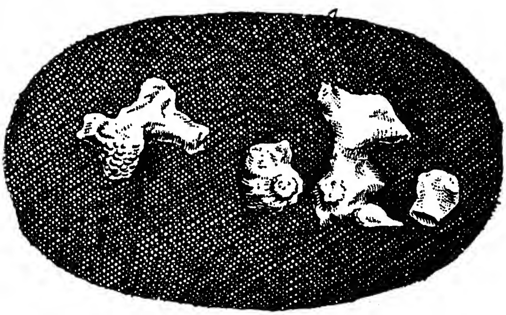
Aug. 5. Dr. FAIRCLOUGH was desired to produce his Bezoar stone again at the next meeting, that it might be looked upon with a microscope, which Mr. HOOKE was ordered to bring with him for that purpose.

Flustra, Teeth of Snail, and Growth on Rose Leaves.

Mr. HOOKE produced three microscopical observations, 1. Of the honeycomb sea-weed. 2. Of the teeth of a snail. 3. Of rose-leaves, having, at the season of the year, when they are withering, a certain plant growing on the back of them.

Earl of Balcarres's Heart-Stones.

Sir ROBERT MORAY produced again the stones taken out of the Earl of BALCARRES's heart, and desired, that the figure of them might be drawn; and Dr. WILKINS moved, that it might be taken in plaster: the care of both which was committed to Mr. HOOKE.



HEART-STONES FROM THE EARL OF BALCARRES.
From Birch, Hist. Royal Society.

Gunpowder Testing.

Mr. HOOKE was appointed to consider of a way to determine the strength of gunpowder by weight.

Stones from Heart of Earl of Balcarres.

Aug. 17. Mr. HOOKE gave in a picture of the stones taken out of the heart of the Earl of BALCARRES.

Long-legged Spider.

Mr. Hooke produced his microscopical observation of a long-legged spider, having two eyes fixed on its back, and standing out upon a stem.

Insects in Rain-water.

The operator produced some rain-water with a great number of little insects in it. Mr. Hooke was ordered to look upon them with a microscope, and to draw the picture of them. The operator was directed to keep these insects, in order to see, whether they would turn into any other kind; and likewise to procure and keep some Barnet water, which breeds worms, chiefly in August.

Gunpowder.

Mr. Hooke showed the figure of an engine for determining the force of gunpowder by weight; and was desired to draw it again, and to add some explication to it.

Water Purged from Air.

Monsieur Huygens's experiment was tried again, and succeeded; the water, which was well purged of air, remaining fastened in a cane of near seven feet, after the engine was very well exhausted.

It was ordered to be tried again, and Mr. Hooke was desired to continue the application of a sucker to it; and to take an exact notice of all the circumstances occurring in this experiment, and to give all in writing.

Classification of Sciences.

Aug. 26. At a meeting of the Society a Latin letter of Dr. Eccard Leichner, of Erfurt in Germany, to the society, dated the 16th of April 1663, relating to a printed book of his sent by him to His Majesty, concerning the design of reducing all sciences, and divinity itself, into order by an apodictical method, and desiring the opinion of the society in this matter, was read, and referred to the consideration of Dr. Wilkins, Dr. Wallis, Mr. Pell, and Mr. Hooke, to make a report thereof to the council, and to draw up something by way of answer to it.

Barnet Water and Insects.

Dr. Goddard produced some of the Barnet waters of two years old in a large glass vessel, which being cracked in one place, some salt was found on the outside of the glass about the crack; which salt put upon a coal melted, and was looked upon as of a peculiar kind.

Mr. HOOKE was ordered to make observations both upon the insects of the rain-water and the Barnet water; to draw schemes of them; and to see whether they will change into other kinds, and to what bigness they will grow.

Sounding, Water-bottle, and Gunpowder Engine.

He produced his explications of the new sounding instrument, and of the vessel, that fetched water from the bottom of the sea; and of the engine for determining the force of gunpowder by weight. He was directed to draw the figures in great against the next meeting, for the better satisfaction of the members.[1]

Pleiades.

He produced a scheme of the Pleiades, as he had lately observed them mingled with other stars; among which he had discovered ten kinds of magnitude below the fifth. He represented in this scheme above eighty stars, whereas GASSENDUS hath set down but thirty-five near the said Pleiades. He was desired to continue these observations, and particularly to make some of the sheath of Orion, the triangular star, &c.

History of Weather.

Sept. 2. Dr. WILKINS put the company in mind to improve their former consideration of making an history of the weather, in order to build thereupon an art of prognosticating the changes thereof: And he suggested, that it might be recommended to some of the members of the Society, to make constant observations, at least of the most considerable changes of weather: in order to which, Mr. HOOKE was desired to engage herein, which he did.[2]

Gnat Larva.

Mr. HOOKE produced a microscopical observation of a worm bred in rain-water, and turned into a gnat.

Gunpowder Engine.

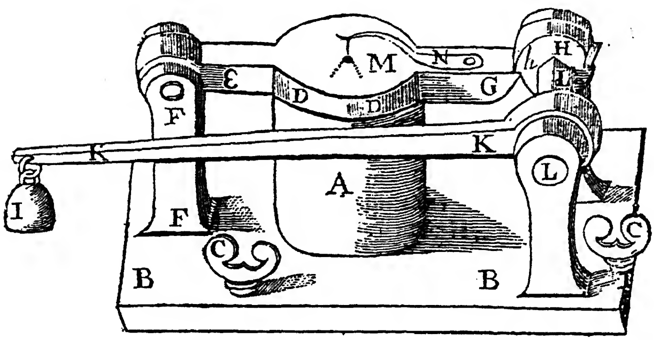
Sept. 9. Mr. HOOKE brought in a scheme of the instrument for determining the force of gunpowder by weight, together with an explication thereof; which was ordered to be registered, as follows:

This instrument for the trial of powder consists of, A, an iron barrel, of what bore and thickness is thought convenient, fastened into an iron plate or pedestal BB, which pedestal may be fastened

[1] Both HOOKE's original diary and his 'figures in great' are preserved in the Royal Society Hooke MS. Nos. 23 and 35. They might be bound together with advantage.

[2] See p. 274.

to any floor or ceiling by the screws CC: this barrel is exactly closed at the top by the cover DD, which is so even and truly wrought, as to touch it very closely, and in every place; one end E, of this cover is fastened by a joint into the pillar FF, the other end G, is kept down very firmly by the end or nick of the nut H: this nut is very powerfully kept in that posture by a weight I, hung upon the end of the beam KK, that is fast upon the same pin LL, to which the nut also is. In the cover is the touch-hole M, tapering outward, which hath a valve so contrived, with a spring N, that as soon as the touch-powder is fired, it is by the valve so close shut, that the strength of the powder



THE ENGINE FOR THE TRIAL OF GUNPOWDER.
The original drawing is in the Royal Society Hooke MS. No. 22.

cannot spend itself that way: a usual inconvenience not provided against in other contrivances.

The way of calculating what proportion of strength, placed at the middle of the cover, is requisite to move the weight I, hung at the end of the beam, is very easy; for it will be as half the distance of the corner *h*, of the nut, from the axis of the pin LL, is to the distance of the weight I, to the force against the cover, which is requisite to move it when so kept down. So that if those distances are in a decuple proportion, five pound hung at I, will keep the cover as strongly down upon the end of the barrel, as an hundredweight set upon the cover DD, can do.

Microscopical Anatomy of Fly.

Mr. HOOKE produced likewise a microscopical observation of the several parts of a fly.

Skin Grafting.

Sept. 16. Dr. WILKINS proposed the experiment of making a piece of the skin of a dog to grow upon another.

It was ordered hereupon, that the experiment should be first tried with a piece of skin cut from the body of a dog, and sewed on again upon the same dog: and Dr. CROUNE and Mr. HOOKE were appointed curators thereof, and the operator ordered to provide a dog against the next meeting.

Grafting Cock's Spur.

Mr. HOOKE was also desired to try the growing of hair, and of a cock's spur upon the head of a cock.

Expansion of Mercury in Glass.

The operator was directed likewise to have ready against the next meeting a cylinder of mercury, to be kept in Gresham College, for the observing the ascent and descent thereof, according to the various constitution of the air; Dr. CROUNE mentioning, that he had found it rise and fall, according to the degrees of cold and heat, but with some air left in the cane; and Mr. HOOKE alleging, that Mr. BOYLE's cylinder had risen in summer, and fallen in winter; and ascribing this effect to the greater quantity of vapours exhaled in summer, causing more gravitation in the air.

Dr. Dee's Weather Records.

Sept. 23. Dr. WILKINS mentioned a person who had considerable collections of observations on the weather, made by Dr. DEE and others. He was desired to make the person acquainted with Mr. HOOKE.

Silk.

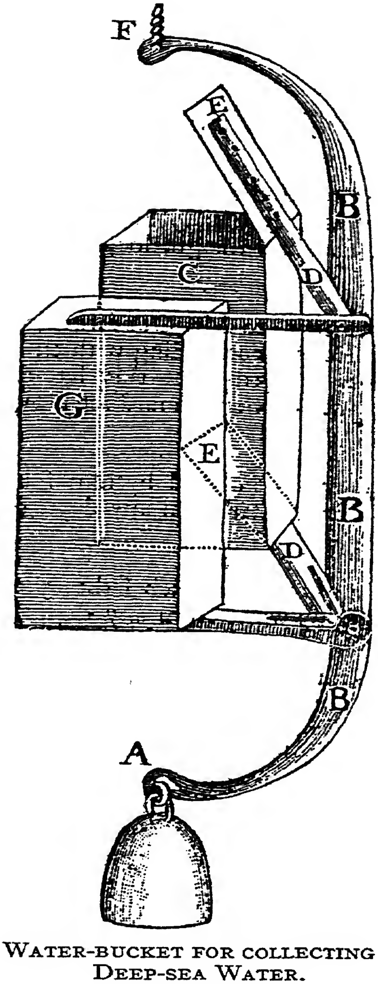
Sept. 30. Some silk from Virginia was given to Mr. HOOKE, to be examined with a microscope.

Sounding and Collecting Water.

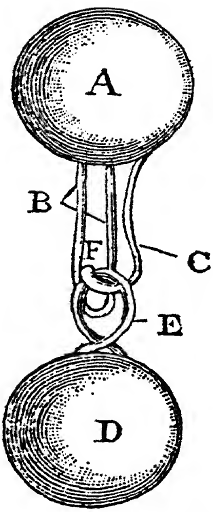
Mr. HOOKE brought in the description of the new ways contrived by him for sounding the depth of the sea without a line, and fetching water from any depth; which were ordered to be registered, as follows:

The way, which I prefer before several other contrivances, which I thought of, for sounding the depth of the sea; and fetching up water from any depth, are these:

The first is with a ball sunk to the bottom of the sea by a weight of lead or stone, the which, as soon as it toucheth it, presently returns toward the top of the water, leaving the weight, behind, which is thus contrived. Between the long wire staple B, of the ball A, I press in with my fingers a springing wire C, on the bended end F, on which I hang the weight D, by its ring E, and



Water-bucket for collecting Deep-sea Water.



Hooke's Sounding Apparatus.

*

so let them down into the water in this posture; towards the bottom of which they are carried with a considerable swiftness; which the weight D touching first, is thereby stopped; but the ball, by the impetus it acquired in descending, being carried downwards a little after the other is stopped, suffers the springing wire C, to fly back, and thereby sets itself at liberty to reascend.

The way for fetching up water from any depth in the sea, is with a square wooden bucket C, whose bottoms EE are so contrived, that, as the weight A, sinks the iron B (to which the bucket C, is fastened by the two handles DD, on the ends of which are the movable bottoms or valves EE) and consequently draws down the bucket, the resistance of the water to its descending, keeps up the bucket in the posture C, whereby the water has all the while it is descending, a clear passage through; whereas, as soon as the bucket is pulled upwards by the line F, the resistance of the water to that motion beats the bucket downwards, and keeps in the posture G, whereby the included water is preserved from getting out, and the ambient air from getting in.

Sole's Scales, Tabby, and Wild Oat.

Mr. HOOKE produced likewise three microscopical observations; 1. Of the scales of a soal's skin, presented by Mr. PELL. 2. Of a piece of tabby. 3. Of the beard of a wild oat.

Childrey's Weather Records.

He was ordered to speak to Mr. CHILDREY, concerning his collection of observations on the weather, and to make report thereof to the Society; as also to try, whether Mr. CHILDREY would grant the perusal of them for the service of the Society.

Council Meeting.

Oct. 5. It was ordered, that Mr. HOOKE be desired to be present at the next meeting of the Council.

History of Weather.

Oct. 7. Mr. HOOKE's paper concerning the observables for making a history of the weather was read, and ordered to be reviewed by the President and Sir ROBERT MORAY, and then to be registered, and sent to the several persons, who had been engaged in this work of observing the changes of weather, as Dr. POWER, Mr. BEAL, &c.[1]

Hygroscope.

Mr. HOOKE was ordered to bring in at the next meeting an hygroscope made of the beard of a wild oat, with an index.

[1] Cf. R. S. MS. No. 24.

Experiments Ordered.

Oct. 12. Mr. HOOKE was also present, according to the order of the last meeting of the Council.

Mr. HOOKE was charged to be curator of the following experiments:

1. To take care of preparing those experiments, that stood upon his account.

2. To make ready the two thermometers of Dr. WREN's invention, one of tin, the other of glass.

3. To make an artificial eye.

4. To try the casting of a picture on a wall in a light room; and to bespeak a concave glass for it.

5. To give order for the making of the engine, to determine the force of gunpowder in by weight.

6. To make a hygroscope with the beard of a wild oat.

Skin Grafting.

Oct. 14. Dr. CROUNE and Mr. HOOKE not having yet met to cut a piece of dog's skin and sew it on again, in order to see whether it will grow; and Dr. CHARLETON affirming, that he had tried this experiment formerly, he was desired to meet on the Friday following, with the other two curators at Gresham College, and there to make the experiment together.

Compressing Engine.

Mr. HOOKE was desired to lodge some days in Gresham College for the well-fitting the compressing engine, and the giving order to the operator for the making the engine described by him to determine the force of powder by weight; as also for the artificial eye, and the perfecting Dr. WREN's new kind of thermometer with two round glasses and quicksilver in them.

Fly and Moss.

Mr. HOOKE communicated two microscopical observations, one of a common fly, the other of moss grown upon a brick, together with the seed.

Keeper of the Repository.

Oct. 19. It was ordered, that Mr. HOOKE have the keeping of the repository of the Society, for which the west gallery of Gresham College was appointed: and

Sounding Gear to be shown to Charles II.

That one of the new instruments for sounding without a line

be made ready by Mr. Hooke, amongst the other things designed for His Majesty's reception.

Hygroscope.

Oct. 21. Mr. Hooke showed a hygroscope, made of the beard of a wild oat, advancing and returning according to the dryness or moisture of the weather.[1]

Fly's Wing.

He likewise produced the microscopical observation of a part of a fly's wing.

Feather Grafting.

Mr. Hooke was appointed curator for the engrafting of feathers upon a cock's comb against the next meeting.

Compressing Engine.

Oct. 28. Mr. Hooke was charged to provide, from time to time, such experiments for the compressing engine, as he should think proper.

Pismire.

He showed a microscopical observation of a pismire.

Sounding.

He was desired to take care and give directions, that Major Holmes might be furnished with a dozen of his new balls with leads for sounding.

Labelling.

It was ordered, that Mr. Hooke, as keeper of the repository, should always affix some note to the things in it, by which it might be known what they are, and by whom they were presented.

Cock's Spur Grafting.

Dr. Charleton, Dr. Croune, and Mr. Hooke, were again appointed curators of the experiment of planting a cock's spur on a cock's head; and the operator was ordered to provide a fit cock for it against the next meeting.

Skin Grafting.

Dr. Charleton was also desired, together with Mr. Hooke, to repeat the experiment of cutting off a piece of a dog's skin, and sewing it on again: and the operator was ordered to provide another dog for that purpose.

Feather Grafting.

The operator tried the experiment of making feathers grow

[1] Cf. Preface to *Micrographia*.

upon a cock's comb, with the mixture of bole-armoniac and the white of an egg.

Mite, Quartz Crystals, and Hair.

Nov. 4. Mr. HOOKE showed some microscopical observations of, 1. A mite. 2. Sparks of a flint. 3. Hairs of a man's head, of a cat, and of a horse, and some bristles.

Sounding.

Mr. HOOKE was desired to try the new sounding balls in the Thames for Major HOLMES, and to give an account of the success to the society.

Prince Rupert's Perspective Invention.

Nov. 11. Mr. HOOKE suggesting, that additions might be made to the invention of Prince RUPERT for casting any platform into perspective, so that it might incline and recline, and be fitted to draw likewise solid bodies in perspective, and to describe all kinds of dials, was desired to bring in these additions in writing, and then to give a description, and to show the practice of the whole. In the meantime it was ordered, that the Prince's instrument should remain simple, as it was then, without any alteration therein.

Rubbed Diamonds Shine in Dark.

Mr. CLAYTON's diamond being again spoken of, the President mentioned, that he had one upon his finger, which being without clouds, would shine notwithstanding, when rubbed in the dark. Mr. HOOKE added, that he had a ring with six small diamonds, which would all do the like, but continue for a very little time.

Power's Planetary Model.

Dr. WILKINS produced an instrument and paper of Dr. POWER, representing and describing the Copernican motion of the sun upon its axis, &c. They were both delivered to the operator, to put the instrument into order, and it was referred to Mr. HOOKE to see, whether it would answer the intention.

Carriage.

Mr. HOOKE showed the scheme of another engine for carriage, viz. of such a one, as goes with one wheel, and is drawn by one horse, so contrived, that it shall not fall, but be kept perpendicular, what way soever it moves, even on the declivity of a hill, &c. He was desired to have a model made thereof.

Sounding.

He being asked, whether he had tried his new sounding balls

for Major HOLMES, said, that he had tried them, and found them to do exceeding well. Oozy ground was observed to be most likely to make them unsuccessful.

Air-bell.

Mr. HOOKE spoke of a way of carrying air down to the bottom of the sea at any depth, and of bringing it up, under a bell. He was desired to give in a particular description of it.

Compressing Engine.

Mr. HOOKE was appointed to provide a good experiment in the compressing engine against the next meeting.

Skin Grafting.

The operator was ordered to have a dog ready for the next meeting, to cut off a piece of his skin. The curators appointed for this were Dr. CROUNE and Mr. HOOKE.

Inventory of Repository.

Nov. 16. Mr. HILL brought in the inventory, drawn out of the Treasurer's bills, of the things belonging to the Society; which inventory was ordered to be delivered by the Secretary to Mr. HOOKE, as Keeper of the repository. Dr. GODDARD also brought in a list of the things committed to his custody; which list was also ordered to be delivered to Mr. HOOKE.

Whale Shooting.

Nov. 18. Mr. HOOKE showed the Society his model for the whale-shooting engine. Some objections being made concerning it, it was ordered, that Dr. WILKINS, Dr. WALLIS, and Mr. HOOKE should meet together on the Tuesday following, in the afternoon, to consider further of it.

Prince Rupert's Perspective Instrument.

Mr. HOOKE was put in mind to bring to the next meeting his additions to Prince RUPERT's instrument of perspective, and to make a full description of it.

One-wheel Engine.

He was also ordered to make a paste-board model of his engine with one wheel, to travel in with ease and speed, and to show it to the Council at their next meeting; as also to prepare a model of his other engine, to travel in over land and water by walking in it, after the fashion of the wheel of a crane.

Carriage.

Nov. 23. Mr. HOOKE produced a model of a new way of carriage

with one horse, after the fashion of a wheel-barrow, devised by himself; and upon some debate it was ordered, that he should further consider of it against the next meeting of the Council.

Prince Rupert's Perspective Instrument.

Nov. 25. Mr. HOOKE brought in an account of his additions to Prince RUPERT'S perspective engine; and it was ordered, that such an engine should be made for the use of the Society.

Whale Shooting.

Mr. HOOKE acquainted the Society, that he had altered his thoughts about the whale-killing engine, conceiving now, that a cross-bow of whale-bones might be so contrived, as to perform that execution well. Whereupon some of the members objecting, that whale-bones would by the water lose their spring, it was said, that good varnish would secure the spring. Others suggested, that a bow of steel tinned over would do well, especially if several thin steel springs were put together. Mr. HOOKE was desired to consider further of this.

Gunpowder Engine.

Mr. HOOKE produced his engine for determining the force of powder by weight: but it being found imperfect, by reason of the non-continuance of the first impulse, he offered to complete it, by the addition of a rammer.

Egg of Silkworm.

Mr. HOOKE showed a microscopical observation of a silk-worm's egg.

Thompson, Maker of Instruments.

Dec. 2. Mr. HOOKE informed the Society, that he had spoken to Mr. THOMPSON, to make Prince RUPERT'S perspective-instrument, together with his additions.

Gunpowder Engine.

The operator was directed also to try the experiment in Mr. HOOKE'S new powder-engine by himself, and then to do it before the Society at their next meeting.

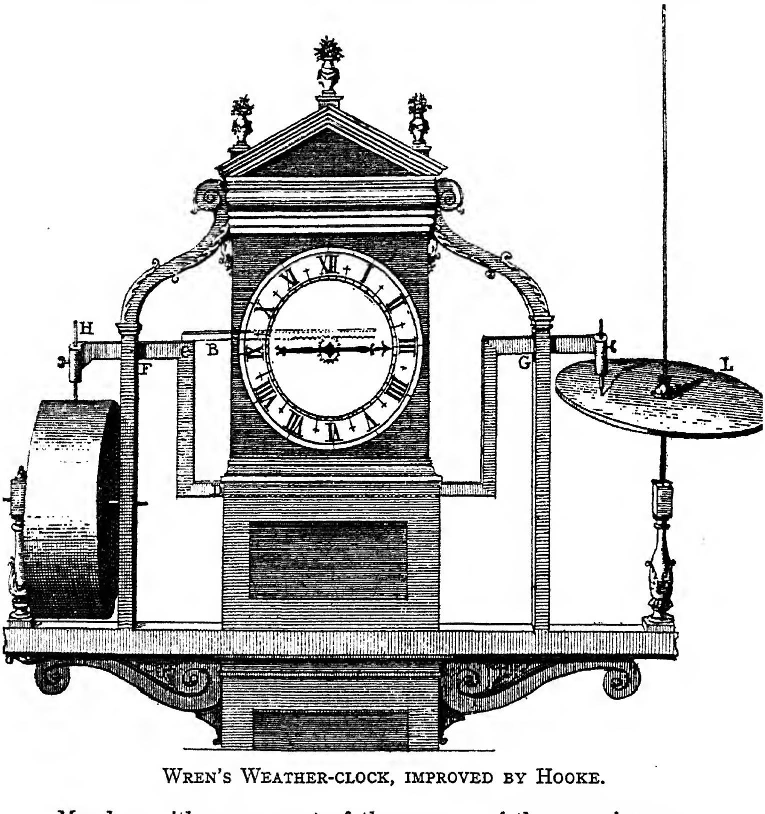
Experiments for Charles II.

Dec. 7. The motion of providing experiments for His Majesty's reception being renewed, and consideration being had of the necessity to appoint a person for the careful preparing thereof, it was voted, that Mr. HOOKE should be invited to lodge in Gresham College four days in the week, viz. Mondays, Tuesdays, Wednesdays, and Thursdays; and that a convenient lodging

should be provided for him, and he allowed twenty shillings a week for that time. Mr. HOOKE was called in thereupon, and this proposition being made to him, he accepted of it.

Experiments for Charles II.

It was ordered, that Mr. HOOKE attend the Council every



WREN'S WEATHER-CLOCK, IMPROVED BY HOOKE.

Monday, with an account of the success of the experiments to be prepared for His Majesty's entertainment:

That the experiments, to be made on Wednesdays at the ordinary meetings of the Society, be considered of by the Council on Mondays, whether they were fit and ready; as also, that some considerable experiments be had in reserve for extraordinary occasions.

Wren's Weather-clock.

Dec. 9. Upon some debate, Dr. WREN's weather-clock was

referred to the Council, to consider of the expenses, and the most convenient way of reducing this engine into practice; as also, of additions to be made thereunto, whereof some were mentioned by Mr. HOOKE.

Weather-glass.

Mr. HOOKE observed, that a common sealed weather-glass might be made applicable to this weather-clock; and he was desired to give a proof thereof to the Society at their next meeting.

Weighing Glass Bubbles.

The experiment of weighing little glass bubbles in the compressing engine was made with success; and Mr. HOOKE was ordered to bring in writing an account thereof at the next meeting.

Gunpowder Engine.

The experiment of trying the force of powder by weight in the new powder-engine contrived by Mr. HOOKE was made twice, but without success both times; once by reason, that the barrel broke in pieces; the second time, because the cover of the barrel bent. It was referred to Mr. HOOKE to think of a way to prevent these inconveniences.

Hair of Deer.

Mr. HOOKE was desired to observe in his microscope some of the deer's hair, what cavities they have: and Mr. CLAYTON promised to furnish him with some deer's hair brought from the Indies.

Killing Whales.

Mr. HOOKE was put in mind to consider further of the bow for killing whales.

Experiments Appointed.

The experiments appointed for the next meeting were one in the compressing engine, and another of exhausting air out of spirit of wine; the former to be made by Mr. HOOKE, and the latter by Dr. GODDARD and Dr. WHISTLER.

Weighing Glass Balls.

Dec. 16. Mr. HOOKE's paper concerning the experiment lately tried before the Society of weighing two small glass balls in the compressing engine, together with deductions, was read, and ordered to be registered.

Weight of Compressing Engine, and Air-gun.

He was desired to repeat at the next meeting, with more

exactness, the experiment made this day of weighing the condensing engine, after it is crowded full of air, to see how it then differs in weight from itself when filled after the natural manner.

He proposed an experiment to be made with the compressing engine, of applying a gun to it, to see, with what force it will be able to shoot a bullet, arrow, &c.

The operator was ordered to prepare a gun for this purpose.

Hair of Indian Deer.

Mr. HOOKE was desired to examine by his microscope some Indian deer's hair produced by Mr. CLAYTON, and to make a report, whether they are tubulous or not.

Prince Rupert's Perspective Instrument.

He was likewise put in mind to press the workman to dispatch Prince RUPERT's perspective engine against the next meeting.

Lignum Fossile.

Dec. 23. Mr. HOOKE was desired to look upon a piece of *lignum fossile,* sent out of Italy, through his microscope.

Weight of Compressing Engine.

Mr. HOOKE's account of the experiment made at the last meeting of weighing the compressing engine with condensed air in it, was read, and ordered to be registered, as follows:

The receiver of the engine being closed, as is usual, and the air in it being condensed into about a quarter of the space it at first possessed (which was known by the gauge included within the receiver) the whole engine was put into a pair of scales, and counterpoised with a weight of seventy-nine pounds and three-quarters.

Then the stop-cock of the receiver being turned, and the included condensed air suffered to go out, the engine grew lighter by an ounce, there being so much added to the engine-side to bring it again to an equilibrium.

The same experiment was ordered to be made again more exactly at the next meeting; and the operator was directed to provide a pair of fit scales for the weighing of the said engine.

Prince Rupert's Perspective Engine.

Mr. HOOKE produced the new perspective engine of Prince RUPERT's invention, together with his own additions, to cast embossed things into perspective, as well as platforms.

It was ordered, that this engine be showed to Prince RUPERT; but that first two rulers of wood be put in the place of the two threads, that direct the parallelism.

Hair of Indian Deer.

Mr. HOOKE produced a microscopical observation of the hair of an Indian deer, which represents it to be like a sponge, not like quills.

Fish-spawn.

Mr. HENSHAW remarked that he had seen fish-spawn having both eggs and little live animals moving up and down in the shell. Mr. HOOKE was desired to make observations of fish-spawns with a microscope.

Specific Gravities.

Dr. GODDARD being called upon for the experiment formerly committed to him of comparing the weights of metals in air and water, and he not having yet made it, it was desired, that he and Dr. WREN and Mr. HOOKE should be joint-curators to provide Monsieur MONCONYS's way of weighing bodies in water. And Dr. GODDARD mentioning another way of doing this, it was ordered, that both ways should be prepared.

Mercury in Glass Tubes.

Dec. 30. Mr. HOOKE produced a little engine for making the descent of quicksilver in glass-canes more discernible. He was ordered to prepare against the next meeting a tube of mercury, and to fit this instrument to it.

Prince Rupert's Gunpowder Tester.

Some experiments were again made in Prince RUPERT's powder-trier, the success of which was, that with common powder, the ferrule being fixed, the body was raised but a very little; but with the like quantity of the same kind of powder, the ferrule being loose, the body was raised to the top. Both which experiments were tried twice with very near the same effect.

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Sand or Water Timepiece.

Jan. 6. Mr. HOOKE was desired to take care, that the instrument for the measure of time, consisting of only one wheel with hollow cameras in it, moving either with sand or water for a good space of time, be made.

Air-gun.

The experiment of shooting with a wind-gun applied to the compressing engine was made, the success of which was, that the condensation being made near half in the globe, the bullet, shot

at the distance of about twenty yards, made a very considerable dent in a door, sufficient to have killed a man. It was ordered, that this experiment should be repeated at the next meeting, and a particular account of it brought in writing by Mr. Hooke.

Freezing.

Dr. Merret having found by experiment, that water frozen, though exhausted, hath store of blebs, and more than unexhausted, Mr. Hooke mentioned, that he knew a way of reducing water into ice without blebs. Whereupon he was desired the next frosty weather to try this experiment, and produce the effects of it before the society; as also to try, whether such ice, shaped into a lens, would serve for a burning-glass.

Experiments Proposed.

Mr. Hooke's application of his little engine to a tube with mercury for the rendering of the ascent and descent of quicksilver more discernible, was referred to the next meeting.

He was desired to prepare, when the weather should serve, that standard for cold, which he proposed at the preceding meeting: And

To weigh a great receiver, both filled with air, and exhausted: and to do this both ways, by weighing it unexhausted first, and then by exhausting it first, and filling it with air again: As also,

To try, whether he could raise a thin and exhausted glass-bubble from the bottom of the receiver of the condensing engine towards the top, by condensing the ambient air of the bubbles.

Invention Beneficial to the World.

Jan. 13. The President acquainting the Council, that Mr. Hooke had discovered to himself, Sir Robert Moray, and Dr. Wilkins, an invention, which might prove very beneficial to England, and to the world, and that he had a good opinion thereof; but that it was necessary, that some experiments should be made for further certainty, before it was made public, which would require some charges not so fit to be put upon the inventor; it was ordered, that the President, Sir Robert Moray, and Dr. Wilkins have power to employ any sum under ten pounds of the Society's money for the said purpose.

Experiments Ordered.

Mr. Hooke was ordered to have his tube for rendering the ascent and descent of mercury more discernible filled with mercury against the next meeting, and to bring it up in the meeting-room:

He was directed likewise to give an account in writing of the

experiment made this day of weighing a great receiver exhausted of air, and filled with air:

To prepare the experiment of raising a thin and exhausted glass-bubble from the bottom of the receiver of the compressing engine to the top, by condensing the circumambient air: And

To repeat the experiment of shooting with a gun applied to the condensing engine, which failed this day.

Experiments Ordered.

Jan. 27. Mr. Hooke was ordered to repeat the experiment of making a little glass-bubble swim in the air, by condensing the circumambient air; and to bring in an account thereof in writing: And

To try the experiment of putting some springs with a weight both in the rarefying and condensing engine, to see what force the different air hath upon them: and likewise to give in writing the experiment of weighing the air in the condensing engine.

Weight of Air.

Feb. 3. Mr. Hooke's account both of the weight of the air in a large receiver 119 English wine pints, and of the proportion of the weight of the air to the weight of the water, was read; and the latter was ordered to be repeated.[1]

Experiments to be Repeated.

It was ordered, that whoever made report of an experiment but once made, should repeat it, for the sake of more accuracy and certainty.

Compression of Water and Glass.

Mr. Hooke was ordered to make the experiments of compressing water and glass, as also that of the swimming glass-bubble, against the next meeting.

Springs Altered by Temperature and Pressure.

He mentioned, that he had exposed springs to the free air; but that, notwithstanding a considerable alteration in the air, he had not found any alteration in the springs.

Mr. Boyle suggested, that a spring might be bent to a certain degree, and put into a cylindrical glass, with ice and snow about it, to see what alteration would be wrought upon the spring.

Mr. Hooke was ordered to try springs with appendent weights, both in the rarefying and compressing engine, to see what effects the rarefaction and condensation of the air produced in springs.

[1] Cf. R. S. MS. No. 25.

Lens of Ice.

He related, that he had taken a piece of ice, and having shaped it into a lens, had found, that though it cast the figure of the sun upon his hand, yet it yielded no heat that was sensible. He was desired to try with it, when there was an opportunity in frosty weather, a lenticular glass, whether it would yield any heat in such a season.

Experiments Suggested.

Feb. 10. Mr. HOOKE being called in [to the Council], and de sired to suggest some experiments, that might be acceptable and useful to the public, suggested, that the experiment of land-carriage, and of a speedy conveying of intelligence, might be considered of.

Weights of Air and Water.

At a meeting of the Society on the same day,

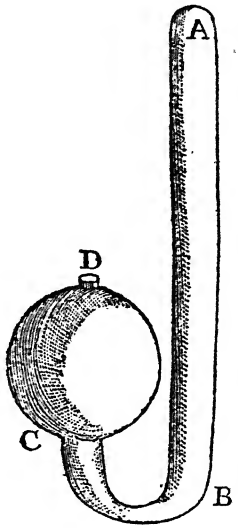
The experiment concerning the weight of air, and the proportion of the weight of air to that of water, was repeated; of which Mr. HOOKE was directed to give an account in writing at their meeting. It was as follows:

A large receiver, holding by measure 119 English pints, was, after a gauge (by and by to be described) hanged into it, closed up with a small stop-cock, and the air was pretty well exhausted by the rarefying engine. Then, the cock of it being well stopped, so as to keep the air from re-entering it, was very well counterpoised in an exact pair of scales: then the stop-cock was returned, and the air admitted; so that the water returned into the longer shank of the gauge, within $\frac{1}{24}$ of the top, and the receiver was found to be grown considerably heavier: the weights, that were added to the counterpoise, to bring it again to an equilibrium, amounting to 2 ounces, 1 drachm, 15 grains, avoirdupois, almost.

The gauge was made of a small pipe of glass, of the shape represented in the figure ABC. The side AB was an even cylindrical pipe, full of air, closed at A; and the ball C was full of water, and the orifice D was left open, to let the air in or out, according to the exigency of the experiment; namely, as the ambient air in the receiver was rarefied, the air contained in the cylinder AB rarefied itself likewise, and broke out into the receiver through the water in C; so that the air in AB was always of the rarity with the ambient air in the receiver: but when the air was admitted into the receiver, it forced the water contained in C into the cylindrical pipe AB, and filled twenty-three parts of twenty-four of it, leaving only a small bubble of air at the top, that filled $\frac{1}{24}$ part of the whole cylinder: whence we collect, that

there was only $\frac{1}{24}$ part of the air, that had a little before filled it, when it was weighed in the scales.

We weighed likewise a pint of water with the same accurate beam, and found it to weigh $18\frac{17}{32}$ ounces avoirdupois; so that the weight of the water, that filled the whole receiver, amounted to $2105\frac{7}{32}$ ounces avoirdupois: from which weight if we deduct $\frac{1}{24}$ part, we shall have very near $2017\frac{1}{2}$ ounces avoirdupois, for



Gauge to Measure Rarefaction of Air.
Original in Hooke's MS. No. 25.

the weight of a parcel of water, equal in bulk to the parcel of air admitted into the receiver, which weighed $2\frac{1}{8}$ ounces: that is, the weight of the air, to the weight of the water, is very near as 1 to $949\frac{7}{17}$.

Experiments Ordered.

Mr. Hooke was ordered to make the following experiments at the next meeting. 1. To immerse a ball in water, and to convey into it a continual stream of air. 2. To try the strength of several kinds of wood, as to bending, toughness, &c. and to break them several ways, both lengthwise and crosswise. 3. To try springs both in the rarefying and compressing engine.

Committee on Diving.

The President moving it to the company, that the business of diving might be taken into consideration as a thing, that

would be, at that time especially, very acceptable, if it could be reduced to practice, it was ordered, that his lordship himself, Sir Robert Moray, Sir William Petty, Dr. Wilkins, Dr. Goddard, Mr. Oldenburg, and Mr. Hooke should be a committee for that purpose, and meet at the President's house on the Saturday following about ten of the clock, and make a report on the Wednesday following.

Speedy Intelligence.

Feb. 17. That Mr. Hooke set down in writing and produce to the Council his whole apparatus and management for speedy intelligence.

Diving.

The experiment of applying a bell or hogshead with air under water by means of two buckets, was tried in little, and succeeded. Whereupon Mr. Hooke was ordered to get made against the next meeting a model of the bag, which was to be about the body of the diver for continual inspiration; which bag being emptied, he was to repair into the bell, as a magazine for a new supply of air to fill the bag with.

Spectacles for Seeing under Water.

For seeing under water, Mr. Hooke proposed a pair of deep convex spectacles.

Life in Air at Various Pressures.

Mr. Hooke was ordered to prepare against the next meeting three vessels, one with common air, another with exhausted air to a certain degree, and a third with compressed air to the like proportion; and to try in them some animals, to see how long they would live in such vessels.

Strength of Wood.

He was put in mind of the experiment of trying the strength of several kinds of wood; upon which Mr. Boyle suggested, that in the trial notice might be taken of the time, when the wood was cut.

Air for Divers.

March 2. Mr. Hooke produced his bellows to be used under water for taking in air; but proposed withal another way conceived by him to be better and safer than that with bellows, viz. with two cylinders open at one end, and having two pipes, by which the air is taken out of the one and put into the other. It was ordered, that two such cylinders be made, and when ready, a waterman hired to try the experiment.

Evelyn's Dinner Party.

March 4. Mr. Hooke, curator to the Society, dined with John Evelyn. Lord Brouncker, Dr. Wilkins, and Sir R. Murray were of the party. [Evelyn's *Diary*.]

Diving Boxes.

March 9. Mr. Hooke produced the leaden boxes to be used under water, for furnishing of air by a couple of pipes, whilst the diver comes out of the bell or tub, and walks up and down working: which air being spent, the diver enters again into the tub or bell for a fresh supply.

It was ordered, that the experiment be made under water with those boxes; and that Mr. Evelyn inquire after the diver about Deptford for this purpose.

Respiration in Compressed Air.

March 16. Mr. Hooke gave an account of the experiment of the last meeting, wherein the air having been compressed to half the room, the bird enclosed in the vessel for the space of about ten hours, was, at the end of that time, taken out very lively, and continued so till the next morning, but then began to sicken, and died towards evening.

Experiments Ordered.

It was ordered, that this experiment should be repeated at the next meeting to a greater degree of compression:

That several kinds of wood be broken at the next meeting: And

That the operator should provide against the same time some tadpoles, to be put into the rarefying-engine; as also to observe what Dr. Charleton suggested, of their being frogs, when the skin is stripped off.

Diver.

The operator giving notice, that there was a man presenting his service to dive, it was ordered, that he should be spoken to for that purpose, as soon as the season would permit; which was done accordingly by Mr. Hooke.

Toad-stones.

Dr. Balle produced a toad-stone, to compare with the teeth of the fish brought in by Dr. Merret at the former meeting. Mr. Palmer and Mr. Hooke, and all who had any such stones, were desired to bring in theirs also, in order to be compared.

Hair of Elephant.

Dr. Wilkins showed the hair of an elephant, which was delivered to Mr. Hooke to be examined in a microscope.

One-wheel Engine, Circular Hour-glass, and Picture on a Wall.

March 23. Mr. HOOKE was ordered to expedite his engine with one wheel, for easy and speedy carriage; as also his circular hour-glass, with several cells therein; and his picture on a wall in a light room.

Microscopical Discourses.

It was ordered, that Mr. HOOKE produce at every meeting of the Society one of his microscopical discourses, in order to their being printed by order of the Society. And that several committees be appointed for the consideration and improvement of several subjects of philosophy.

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Bird in Compressed Air.

March 30. Mr. HOOKE gave an account of the experiment of compressing the air to a quarter, with a little bird in the engine; which having continued therein from eleven in the morning till ten at night somewhat panting, was then taken out, and grew lively enough, yet sickened next day, but was soon well again, and remained alive at this day.

It was ordered, that because in the former experiment of this kind, the bird died, and the cause thereof was by some suspected to be the smell of the cement, trial should be made, whether it were so or not, by putting one bird into a glass with common air, closed with clay, and another into the compressing engine, with common air likewise, but closed with cement, to see, which of these two birds would do best, and live longest.

Expansion of Glass.

Mr. HOOKE was ordered to make at the next meeting the experiment to prove, that glass will stretch.

An experiment was made in a bolt-head with a long small stem filled with cold water, and then put into warm water; whereupon it sunk to half an inch, whereas otherwise it rises by warmth. The cause of this sinking was by some ascribed to the stretching of the glass by warmth. It was ordered to be repeated at the next meeting.

Committees.

Mr. HOOKE served on the following several Committees of the Society:

1. Mechanical. To consider and improve all mechanical inventions.
2. Astronomical and Optical.

3. Anatomical.
6. For Histories of Trade.
7. For collecting all the phenomena of nature hitherto observed, and all experiments made and recorded.

Bird in Compressed Air.

April 6. An account was given by Mr. HOOKE of the two birds, that were put, one into a glass with common air, closed with clay; the other into the compressing engine with common air likewise, but closed with cement, viz. that the bird in the glass, after it had been kept there eight hours, remained alive and pretty well; but the other bird closed up with cement, died within the same time. It was desired, that a way might be thought of to remedy that smell, which seemed to be the cause of the bird's dying in the condensing engine.

Expansion of Glass.

The experiment of stretching glass was made by Mr. HOOKE, who was desired to give an account of the manner and success thereof in writing.

The experiment of making cold common water, put into a bolt-head with a long and small stem, subside with warm water, and rise with cold, was repeated; and Mr. HOOKE desired to bring in an account of it in writing.

Compression of Water.

April 13. Mr. HOOKE mentioned, that he had another way of compressing water, which he was ordered to prepare for the next meeting.

Mr. BOYLE likewise took notice of an experiment of compressing water to be made some weeks after.

Mr. HOOKE affirmed, that water in a trial of his would not compress sensibly with that force, which would compress the air into the 11th or 12th part.

Expansion of Glass and Water by Heat.

An account in writing was brought in by Mr. HOOKE[1] of two experiments tried before the Society at the preceding meeting. 1. Of the raising of water in a bolt-head upon immersion in cold, and falling upon the immersion of it in hot water. 2. Of the stretching and shrinking of glass upon heating and cooling: both which were ordered to be registered, as follow:

There was taken a large bolt-head, containing about two quarts, which was filled with water till it rose about a foot in

[1] Cf. R. S. MS. No. 27.

the stem (which was small) then the station of the water being marked, it was immersed in warm water, whereupon the water in the slender stem fell about half an inch; but upon continuing in that warm liquor, it by degrees reascended, and surmounted its former height.

Afterwards, while yet pretty warm, it was immersed in cold water; whereupon the water rose about a quarter of an inch, but upon a longer stay in that medium, it fell again to that place from which it had ascended, and afterwards below it.

The reasons of which phenomena seem deducible from the stretching and shrinking of the glass upon the sudden access of heat and cold, before these qualities can alike affect the included water.

To prove the stretching and shrinking of glass upon heating and cooling, there were made these trials.

There was taken a hollow cylinder of glass, about a span long, sharpened and sealed up at both ends. This was fitted between the centres of a turning-lathe, so that it would be very easily moved and turned round whilst cold, but upon the heating the middle of this glass with the flame of a candle, it stretched so far in length, that it could not without much difficulty be turned round: but afterwards upon cooling, it shortened and returned to its former laxity, being as easy to be moved as before.

Because it was objected, that possibly the rarefaction of the included air might be the cause of this stretching, the same experiment with the same success was tried with the same cylinder opened at one end, so that the air had a free passage to and fro.

Specific Gravity of Lead.

There was made an observation concerning the proportion of the weight of lead to that of water; of which Mr. Hooke was ordered to bring in an account in writing at the next day.

Experiments Appointed.

The experiments appointed for the next meeting, besides the above mentioned concerning the compresssion of water were as follow: 1. The prosecution of the breaking of several sorts of wood by weight, and particularly of cutting two straight pieces out of the middle of some oaken billet, wherein the grain will run arching. 2. The Magdeburg experiment with two bottles opening into one another, one containing water, the other air only, to be exhausted.

Experiments with Wood.

Mention was made by Mr. Hooke, that a way might be considered of petrifying wood: of softening wood for easy carving,

and then hardening it again; and of hardening wood, and making it lasting by boiling it in tar. The discourse of these particulars was referred to the next meeting.

Compression of Spirit of Wine.

April 20. Mr. HOOKE showed the experiment of compressing spirit of wine by a small glass-pipe in the manner of a spring; which so far succeeded, that there was a sensible compression of the spirit. He was ordered to try it at the next meeting with common water tinged.

Experiments Appointed.

The experiments appointed for the next meeting were, 1. The Magdeburg experiment. 2. To compress water tinged. 3. To boil wood in tar. 4. To show the ascension of water in siphons. 5. To prosecute the experiment of breaking wood by weight.

Two-wheeled Engine, Grinding Engine, Wheel-making Instrument.

April 27. That Mr. HOOKE direct the making of the two-wheeled engine, and the instrument for grinding glasses; and bring in a description of the instrument to make wheels for watches and clocks.

Magdeburg Experiment.

At the meeting of the Society on the same day,[1]

The Magdeburg experiment with two glass-bottles joined together by a stop-cock, whereof the lower was filled with water, the other had nothing but common air in it, was tried, by applying it to the pneumatic engine, and exhausting the air out of the upper bottle; whereupon the water in the lower bottle, the stop-cock being opened, spouted up into the upper bottle, abundance of bubbles of air also rising after it into the same.

It was ordered, that the same experiment be repeated at the next meeting in other positions of the glasses, so that the water be above, and the air below; and that an account of both be brought in by Mr. HOOKE.

Compression of Water.

The experiment of compressing water tinged was tried, and succeeded, though but to a very small degree of compression: and Mr. HOOKE was ordered to give an account of it in writing.

Bird in Compressed Air.

Mr. HOOKE was put in mind to make the experiment with a bird in compressed air, after another manner, at the next meeting.

[1] Under this date is a description of an experiment of mixing water and spirit of wine. R. S. MS. No. 28.

Magdeburg Experiment.

May 4. The Magdeburg experiment was tried again in another position with success. It was ordered to be tried the second time at the next meeting, by exhausting the air out of the upper glass, and afterwards out of the water in the undermost glass.

Aurum Fulminans.

It was ordered, that the experiments of *aurum fulminans* in steel balls be prosecuted; and that Mr. HOOKE provide balls fit for that purpose.

Mr. HOOKE was likewise directed to provide against the next meeting some *pulvis fulminans* of sulphur, saltpetre, and salt of tartar, as a *succedaneum* to *aurum fulminans.*

Diving.

Mr. HOOKE was ordered to agree with the diver between that day and the Wednesday following, to the end, that at the next meeting a day might be appointed for a trial of the new way of diving proposed by himself.

It was ordered likewise, that Dr. CROUNE, Dr. BALLE, and Mr. HOOKE take care at the next meeting to cut off some skin of a dog; and that the operator provide a dog for that purpose.

May 9. Observation of Jupiter's satellite, see p. 196.

Breaking of Glass-drops.

May 11. Mr. HOOKE proposed an experiment, to show in what figure the glass drops are broken by dipping them in isinglass, and wrapping them about with some leather tied about with thread. He was ordered to make this experiment at the next meeting.

A description of this experiment, and a discourse upon it, and some other phenomena of glass-drops, made by Mr. HOOKE, were read; and he was desired to show the following experiment mentioned by him in the said discourse, viz. Take a glass-cane about a foot long, seal up one end, then put in a very small glass-bubble, almost of the shape of an essence-vial, with the open mouth towards the sealed end: then draw out the other end of the pipe very small, and fill the whole cylinder with water. Then set this tube by the fire till the water begins to boil, and the air in the bubble be in good part rarefied and driven out: then, by sucking at the small pipe, more of the air and vapours in the bubble may be sucked out, so that it may sink to the bottom. When it is sunk to the bottom, in the flame of a candle or lamp nip up the slender pipe, and let it cool. Whereupon it is obvious to observe first, that the water by degrees will subside and shrink into less room: next, that the air or vapours in the glass will expand themselves so, as to buoy up the little glass:

thirdly, that all about the inside of the glass pipe there will appear an infinite number of small bubbles, which, as the water grows colder and colder, will swell bigger and bigger, and many of them buoy themselves up, and break at the top.

Diving.

It was ordered, that the President, Sir ROBERT MORAY, Sir PAUL NEILE, Sir WILLIAM PETTY, Dr. WILKINS, Dr. GODDARD, Mr. HENSHAW, Mr. HILL, Mr. OLDENBURG, and Mr. HOOKE be a committee to see the experiment made of diving with the leaden box and pipe, on the Tuesday following in the afternoon, meeting at Sir ROBERT MORAY's chamber; and that the operator appoint the diver, and make the instrument ready for that time.

Fulminating Powder.

The experiment of heating both common and fulminating powder in steel balls was referred to the next meeting, and Mr. HOOKE was ordered to provide fulminating powder.

Testing of Gunpowder.

May 18. The experiment concerning the force of common gunpowder was tried by putting a small thimbleful of such powder into a thick cylindrical piece of steel, having a little cavity in the middle, and closed with an exact screw; which being heated in a coal-fire, burst in two places, throwing out the screw. It was ordered, that the experiment should be repeated at the next meeting in as strong a piece of steel, as could be well made, and with as much care of preventing any vent, as might be. And Mr. HOOKE was appointed curator thereof.

Diving.

Sir ROBERT MORAY gave an account of the diving experiment, and the unsuccessfulness thereof at the first trial. It was ordered, that the diver should pursue the experiment, by attempting frequent practices thereof; for which end the engine should be left with him. Mr. HOOKE was ordered to take care of the performance of it, and to make a report to the society of the success.

Softening Steel.

Mr. HOOKE mentioned, that he knew a person, who had the art of softening steel to that degree, that it might be twisted. He was desired to endeavour to get the secret, and to offer a reward for it.

Breaking of Glass-drops.

Mr. HOOKE tried his experiment of breaking a glass-drop dipped in isinglass, and tied about in a piece of leather; but it not succeeding, he was ordered to try it again at the next meeting.

Testing of Gunpowder.

May 25. The experiment with common gunpowder in a cylindrical piece of steel with a little cavity, screwed close, was tried again, but without success; the powder finding vent between the steel case and the screw. It was ordered, that Mr. HOOKE should provide the strongest method he could, against the next meeting.

Boyle's Experiments.

Mr. BOYLE acquainted the Society with his intended recess into the country, and being desired to bring in writing the account promised by him, of the Pascalian experiments, before he left London, made answer, that he would leave this matter with Mr. HOOKE to prosecute the said experiments, and to give an account thereof.

Diving in the Thames and in a Tub.

It was ordered, that the diving experiment should be prosecuted in the Thames; and that it be made likewise in a tub before the Society at the next meeting; when the diver should be summoned to attend.

Gunpowder.

June 1. The experiment of breaking a case of steel with gunpowder was repeated; and there was taken two pennyweight and an half of powder, and put into the little cavity of the said case, and a screw wrought into it as exactly as was possible. The event was, that the case being heated, the powder broke a little hole through the bottom of it. The Society conceiving, that the case was not wrought equally strong, ordered, that it should be tried again at the next meeting, and that the case should be as even and strong as could be; and Mr. HOOKE be the curator of the experiment.

Diving.

The diving experiment was tried, by sinking the leaden box with air under water in a tub, and letting the operator respire the air in the said box by a pipe, his nose being kept stopped all the while of his drawing in the air of the box, which lasted four minutes by a minute-watch, but might have been continued longer, if the operator had stood in a more convenient posture.

Experiments Ordered.

Mr. HOOKE was ordered to bring in two or three good experiments at the next meeting.

Dr. Dacres's Election.

June 8. The validity of Dr. DACRES's election into the place of Professor of Geometry in Gresham College[1] being questioned, upon information given, that the Lord Mayor of London was not of the committee, and yet by his presence had carried the election by a casting vote; it was ordered, that Dr. WILKINS, Mr. PALMER, and Mr. COLWALL be desired to consult Mr. ELLISE about this business, how it might be redressed, to do justice to Mr. HOOKE, who had five votes, whereas Dr. DACRES had but four, exclusive of that of the Lord Mayor; and that in order to this redress, they should well inform themselves, whether the Lord Mayor was nominated one of the committee; or else, whether he was of custom authorized to be always of every committee, if he pleased to be so.

Gunpowder.

The powder experiment was tried again with a stronger case of steel, and the quantity of two pennyweight and an half in the small cavity thereof, the screw being very exactly put in. The event was, that the case cracked on the upper side, the screw remaining firm in its place. It was ordered, that it should be repeated at the next meeting with a yet stronger case, a less cavity, and less powder, and as deep a screw as might be.

Breaking Wood.

The experiment of breaking two pieces of fir, one horizontally or transversely, the other perpendicularly or directly, was made after this manner: each piece was cut across the grain: both were of an inch diameter in the place where they were to be broken. One of them was laid horizontally; the weight put on at six inches distance from the place where it was to be broken, which was done with 9 pounds 4 ounces and a quarter, besides the weight of the piece itself of eight inches long, and an inch and an half square. The other was broken perpendicularly in the place, in which it was designed to be broken; which was done by 163 pounds and ¾ of an ounce. It was ordered, that this kind of experiments be prosecuted by Mr. HOOKE in other kinds of wood, to see, whether the same proportion holds therein.

[1] Upon Mr. ISAAC BARROW's resignation of the professorship of geometry in Gresham College, the Royal Society, who met there, were desirous, that Mr. HOOKE might be chosen to succeed him; since by that means he would be near at hand to attend their service, with greater readiness for them, and less trouble to himself. But ARTHUR DACRES, M.D. being competitor with Mr. HOOKE, the election was declared in favour of the former on the 20th of May 1664, and he was accordingly admitted, but resigned upon the 20th of March following, and was succeeded by Mr. HOOKE. Dr. WARD's *Lives of the Professors of Gresham College*, p. 169.

Thunderstorm.

Mr. Boyle related some observations of his concerning the effects of a clap of thunder and lightning on the 7th of that month of June, about four in the afternoon, about the sign of the Poet's Head on the highway, going up from St. James's House. This account was seconded by the following one of Mr. Hooke in writing,[1] which was ordered to be registered, as follows:

I had almost all the morning observed very odd commotions of the air, such as I have several times before taken notice of to precede thunder: that is, I took notice by means of the motion of several clouds, that were in very different stations as to their height, that there were several very swift currents of the air above, the highest moving very swiftly to the north, the next below that toward the south-east, and the air below was very variable, and for the most part differing: and this was much more conspicuous, by reason of the clouds, a little before the thunder began, which was about three o'clock.

I had taken notice of several pretty big claps of thunder before that, and had likewise observed what I had done very often formerly at other times; namely, that the rumbling noise after the first great clap seemed to be several echoes from distant places: next that presently after the noise of the thunder-clap, the rain began first to fall; and if it rained when it thundered, it immediately after the clap poured down much faster, much as if a gale of wind had suddenly shook a tree, all whose leaves are full with drops of water.

The flash of the lightning, and the noise of the thunder, were both as great as I have seen or heard in the day-time; the light being so great, that I started at it, it giving a sudden glaring flash of light upon the paper, on which I was looking, as if some powder had been kindled hard by me; and presently looking out of my window, which stood open, I heard a hideous crack of thunder, which seemed to me just over the very house where the mischief was done.

About an hour or two after I was informed of the hurt the lightning had done to a man and a house in Piccadilly, just over against St. James's; and going immediately to see it, I found the outside of the house in several places torn, the west corner of the roof being very much torn, the tiles being thrown off, the laths beat inward, and a good part of the brick wall thrown out into the street: the great middle bars of the western windows were strangely torn; the whole pieces of timber much shaken, and yet for the most part the glass, that was near it, was whole. It had much torn likewise the timber, bricks, and glass of the highest north-west window; the lowest north-west window was

[1] R. S. MS. No. 29.

singed as it were in two or three places, and the lead a little melted, and the timber somewhat blacked; but the glass was not broken, that was held by those melted leads. It had likewise broken a great splinter out of a door that looked eastward, and much torn the brick wall hard by it.

Going into the house I found the man, that had been hurt with the lightning, who was an old bird-catcher: he was very much bruised about the face and all bloody, spitting out of his mouth very much blood, which seemed to come from his mouth only, and not from any hurt within. I could not get any words from him, but the man, that was by him when he fell, and was struck down upon his knees also, told me, that he felt nothing but a sudden strong wind; but that the other was struck down dead, or in a swoon. The man the next day was pretty well, but very sore about the head and face. Viewing the house from top to bottom, I found the highest room or garret to be most hurt. The ceiling just under the place, where tiles were beaten off, was beaten all down upon the floor, and through the brick wall just by it there was a hole made about an inch over, as if a bullet had broke in; and from it to the window, which was about a yard, the wall was razed very deep, as if a great bullet had razed it; and the window was very much shattered and razed as if it had been beaten; but there was no sign anywhere on the wood of the impression of a bolt, but several parts of the wall were razed, as if bullets had grazed on them.

A fellow, that kept the gate, told me, that he was standing at his door when the flash came, and that he saw it come from over St. James's House, and dart upward toward this corner with exceeding great celerity, looking like a piece of glowing red-hot iron: that he saw not whither it went, but heard a great noise at the corner house, besides the hideous crack of thunder. That presently looking into Piccadilly, he saw a peas-cart overturned, horses and all, and the two men fallen: a woman sitting in the cart was much bruised by the fall of the cart upon her, but the horses were not hurt. There were also several brickmakers and carpenters on the other side of the way, which were all overturned by the violence of the wind, but none hurt.

One, that was sitting for shelter under a penthouse, told me, that he saw not the fire, but only the light of the flash; that two men, that were at the other side of the board against which he leaned, were both stricken backwards, but without any hurt. That it removed him from the corner to the middle of the seat, but hurt him not. That he smelt a great smell of brimstone, and was almost deaf with the noise of the crack: in which last particular they almost all agree, some saying it smelt like brimstone, others like gunpowder.

I could not perceive any sign of fire, but only in one place of the outside of a window, where it had a little melted the lead, and a little smutted or singed the place; most of those effects seeming to have proceeded from a violent motion of the air.

Magnetic Variation.

June 15. It was ordered, that Sir ROBERT MORAY, Mr. BALLE, and Mr. HOOKE should meet at a time convenient for them to make an observation concerning the variation of the needle, which was affirmed by Mr. BOND to be then 1° 30′ westward.

Effect of Cold on Loadstones.

Mr. BOYLE mentioned, that it would be worth trial what power intense cold hath upon loadstones, by enclosing some of them in ice in winter.

Mr. HOOKE affirmed, that a loadstone in winter taketh not up so much iron, as in summer.

Gunpowder Experiment.

The experiment of powder in a case of steel, much stronger than before, was again tried, but without any report or other visible effect; which was ascribed to the want of sufficient heat. It was ordered, that the fire be made strong enough at the next meeting for the repeating of the experiment.

Wood Breaking and Hardening.

There were made two experiments of breaking wood.

Mr. HOOKE was put in mind of the experiment proposed formerly by him of rendering wood hard and tough for duration by boiling it in tar.

Mr. HOWARD suggested, that this experiment might be tried upon willows.

Refraction.

Mr. HOOKE proposed, that a certain instrument contrived by him might be made, to try refractions in, whether they hold by sinus's.

Cutlerian Lectures.

June 22. It was ordered, that Mr. HILL and Mr. HOSKYNS confer with Sir WILLIAM PETTY and Mr. GRAUNT concerning the manner and form, in which it might be most proper for Sir JOHN CUTLER to put in execution his promise of giving fifty pounds a year to Mr. HOOKE during his life for the reading of the histories of trades in Gresham College.

Microscopical Observations.

It being mentioned, that in case Mr. HOOKE's microscopical

observations should be printed by order of the Society, they might be perused and examined by some members of the Society; the Lord Viscount Brouncker was desired to undertake this perusal, and to communicate the manuscript, after his perusal of it, to whom of the Society he should think fit.

Spectacles for Divers.

The operator reported, that the diver had been under water with the new instrument a pretty good while; but that he wanted some fit glasses for his eyes.

Mr. Hooke promised to prepare a pair of convenient spectacles for that purpose.

Experiments Appointed.

The experiments for the next meeting, besides the above mentioned, were appointed: 1. The choking and reviving of chickens, by Dr. Croone. 2. The celerity of falling bodies with Mr. Hooke's new instrument, to be tried from Mr. Wilson's room. 3. To cut the steel case, wherein the powder experiment was formerly tried in a good fire without any report, to see what is become of the powder.

Refraction.

It was ordered, that the instrument proposed by Mr. Hooke for measuring refractions, should be made with all speed.

Generation of Flies.

June 29. Sir Robert Moray produced a glass with dead Cantharides in it, that had been there so for the space of three years, the mouth of the glass having been covered with a paper; but there appeared in it some small living flies, supposed to be generated from the dead Cantharides. It was recommended to Mr. Hooke, to look upon the flies with a microscope.

Viper's Tooth.

Dr. Goddard moved, that Mr. Hooke might be desired to view a viper's tooth in a microscope, and to give an account of the observation to the Society.

Experiments.

Mr. Hooke was desired to think upon one or two experiments more for that meeting.

July 5.[1]

LETTER FROM HOOKE TO BOYLE.

Most Honoured Sir,

There has very little happened since you left *London*, that

[1] The date of this letter has been supplied by the context.

I have met with worthy your knowledge. I did (as I remember) acquaint you with the success of the powder enclosed in an iron, which neither broke the case, nor was perceived to go off. Upon opening this last Wednesday, there was found a pretty quantity of a black dirt, which laid on paper presently dissolved like an alcali: some of it put on a coal did not at all burn like salt-petre, sulphur, or gun-powder. The same experiment will be tried again with double the quantity of powder, which will be a noble experiment, if it break not the vessel, nor force itself away between the plug and the hole; which last I guess will be almost as difficult as the former; for the plug is made of steel, and by screwing makes its own way in, and besides the heat will make them, if possible, fit closer together. And indeed upon viewing the last, I could find no sign, by which I could guess it to have leaked, unless the alcalisate nature of the included substance be one, of which I can say nothing. Some experiments we made of breaking wood, which were considerable, and gave occasion to hope, that this subject will afford many useful experiments. We had a relation of a way of discovering the sholes of fish from the top of certain hills in *Cornwall* and in *Ireland*, which was seconded by many testimonies, and is indeed a very philosophical one, and may afford good hints. The story in short was this.[1] That in those parts it is usual for a man standing on the top of some hill near the sea, to discover, where the fish lye in the sea, and which way they move, and from thence by certain signs with his feet, and hands, and hat, to direct the fishermen on the water, who can perceive nothing of what he on the mountains sees, though they be just over the shole of fish. Some observations, somewhat like this, I remember I have often taken notice of, from the tops of hills near the sea side, whence I could perceive plainly, how far the rock ran out into the sea, though they were covered with water to a great depth, which I could not at all see, when I was on the water in a boat, which made me think (and this of the Cornish men has confirmed me) that all the appearances in these parts of the moon, which are accounted the sea of it, may this way be solved. And this minds me to acquaint you with an observa-

[1] Doubtless the story of Mr. Southwell on Pilchard fishing of June 29, 1664.

tion I made several nights this last week with a telescope not above eight inches long, wherewith I could plainly see the satellites of Jupiter and Saturn oval, though not angulated, and the body of Jupiter appeared full as big as with a four foot glass; which shews what one might expect, if we could make object glasses, that would bear a large aperture and a deep charge. We shall to morrow make a good experiment of the velocity in the vibrations of a sounding string, of which I shall acquaint you by the next. There is a gentleman here in town, that has a better way of teaching musick than what KIRCHER causelesly enough vaunted his *Ars Combinatoria* to be, whereby he has presently taught the duke of BUCKINGHAM to compose very well, though he knows nothing of the practick part of musick. For business; here has been lately the queen's receiver to demand rent for *Stalbrige*, and has desired to have an answer sent him as soon as I could. Mr. LONGE has been here likewise to desire some spirit of harts-horn and ens Veneris for Dr. CLODIUS, because he cannot get any of Mr. PULLEIN, and the doctor has not as yet, it seems, any conveniency of making it himself. Here was yesterday Dr. WILLOUGHBY of *Merton* college in *Oxford*, to have waited on you, and desires to have his humble service presented to you. As for my own business, wherewith I acquainted you before your departure, I cannot get any settlement of it, and know not as yet what it may prove, but I fear it is very dubious. Nor is there any thing done in the other business, the one, I think, hindring the other. The condensing engine and the scales I have now by me, but did not send them, because I hope my lord ORRERY's safe arrival will hasten your return to town. The pipes likewise are ready; and if there be any thing else you desire to be provided against your coming, they shall, upon the receiving of your commands, be speedily provided by,

Most Honoured Sir,
your most faithful, and
most obliged humble servant,
ROB. HOOKE.

Mr. OLDENBURG desires to have his service presented to you.

Common Flies.

July 6. Mr. HOOKE being called upon to give an account of

the flies found alive in the glass with the dead cantharides, produced at the preceding meeting, said, that having looked upon them with a microscope, he found them to be not young cantharides, but ordinary flies.

Fulminating Powder.

Mr. HOOKE was desired to bring some of his fulminating powder, to be tried in the steel case at the next meeting.

Experiments Appointed.

The experiments appointed for the next meeting were; 2. To try the velocity of falling bodies with Mr. HOOKE's new instrument. 5. Mr. HOOKE's experiment with a glass-cane and glass bubbles in it.

Velocity of Sound.

The experiment of the velocity of a sound's being propagated was likewise repeated, and prosecuted by lengthening the wire to 272 feet; and it was found as before.

Velocity of Falling Bodies.

The experiment of measuring the celerity of falling bodies was tried; but the wind disordering the string, on which the ball hung, it was referred to the next meeting; order being given to prepare a board for the balls to fall upon without a string; as also to try, besides balls of lead, other bodies of the same magnitude and figure.

Magnetic Variation and Loadstone.

Sir ROBERT MORAY made some report of the observation of the variation of the needle, viz. that much uncertainty was found in it, the needle standing one time between 1° and 1° 30′ westward, another time about 1° 30′ eastward; but at last directly north and south. It was ordered to repeat the observations as often as conveniently might be, and that Mr. HOOKE should bring in writing the whole apparatus and all the circumstances of the observations.

Mr. HOOKE mentioned, that he had seen a little loadstone lift up 150 times its weight.

Gunpowder Experiment.

The experiment of firing gunpowder in a steel case was tried again; but no report was heard, nor anything broken in the vessel.

Mr. HOOKE moved, that the experiment might be made with fulminating powder.

It was ordered, that both these experiments should be made,

and that it should likewise be tried, whether *aurum fulminans* and *pulvis fulminans* give a flame, when fired.

Experiments Ordered.

July 20. The experiments ordered for the next meeting were:

4. Of measuring refractions by Mr. HOOKE's new instrument.
5. Of firing both gunpowder and fulminating powder.
6. Of trying, whether *aurum fulminans* and *pulvis fulminans* will flame, when fired.

Curator to Live in Gresham College.

July 27. It was ordered, that at the first opportunity Mr. HOOKE be put to the scrutiny for the place of Curator:

That he should receive eighty pounds *per annum*, as Curator to the society by subscriptions of particular members, or otherwise:

That he forthwith provide himself of a lodging in or near Gresham College:[1] And

That these orders and votes be kept secret, till Sir JOHN CUTLER shall have established Mr. HOOKE as professor of the histories of trades.

Experiments Ordered.

It was ordered, that this experiment of the celerity of falling bodies be further prosecuted at the next meeting; and that *aurum fulminans* and *pulvis fulminans* be fired in a dark corner, to see, whether they would flame; and that the instrument for measuring refractions be prepared.

Velocity of Falling Bodies.

Aug. 3. The experiment of the velocity of descending bodies was tried with three leaden balls of different sizes; the diameter of one being $1\frac{73}{100}$ inch; of the second, $1\frac{37}{100}$ inch; of the third, $\frac{99}{100}$ inch. The height of their descent was sixty-one feet; the time three vibrations of half-seconds and 15‴ or 16‴. So that the difference between them was but 1‴.

Mr. HOOKE was desired to find some convenient place in Westminster or Paul's for the prosecution of these experiments in a place free from wind; and to request such persons of the society for his assistance, as he could get.

Experiments to be Made.

Aug. 10. Mr. HOOKE was desired to bring a list of experiments to be made before the Society on their meeting days.

[1] Mr. HOOKE accordingly settled in Gresham College about the end of August or beginning of September 1664; for in a letter to Mr. BOYLE dated October 6, printed in Mr. BOYLE's Works, vol. v, p. 537, he takes notice, 'that he had been *full five weeks* settled there'.

Refraction.

Aug. 17. The engine to measure refractions was produced, examined, and approved of, and Mr. HOOKE, the inventor of it, appointed to begin at the next meeting to try experiments in it; as also to give a description of this engine, to be kept in the Register book.

Velocity of Falling Bodies.

Mr. HOOKE made report, that a leaden ball descending fell in the first second of time of fall $15\frac{1}{2}$ feet, being tried by him several times; and that the descent holds in a duplicate proportion. It was ordered, that this experiment should be carefully prosecuted by him with balls of several sizes and different materials, and in particular with bodies of a cylindrical figure.

Wood Breaking.

It was ordered, that the experiment of breaking several sorts of wood be prosecuted by Mr. HOOKE; and that they should be made upon the same kinds of wood of several ages, grown in several places, and cut at different seasons of the year.

Velocity of Bullets.

Aug. 24. There was made an experiment for finding the velocity of a bullet by means of the instrument for measuring the time of falling bodies; which was so contrived, that the pendulum was set on moving by the bullet's passing out of the mouth of the carabin, and a board was put up for a mark at a determinate distance, and a string extended from that board to the pendulum, which was fixed just by the gun. It was thought, that by means of that string, which was stretched pretty stiff, and so contrived, that a small thrust against the board would stop the pendulum, the impulse of the bullet against that board would be presently communicated back to the pendulum, by which means that vibrating body being stopped at the very instant, would have shown the time, that the bullet was passing from the mouth of the piece to the board or mark. But it was found upon several trials, that the bullet pierced through the board, which was three inches thick, and did not break a small slender piece of white thread, which was to have stopped the pendulum.

It was ordered, that Mr. HOOKE should consider of a better way to try this experiment against the next meeting: And

Velocity of Sound.

That Dr. CHARLETON and Mr. HOOKE be curators for finding the velocity of sounds with small and great guns, with and against the wind.

Pendulum Experiments.

Mr. HOOKE reported to the Society, that he had begun to make experiments upon the top of St. Paul's steeple for measuring the time of the vibrations of such a pendulum, as reached from the said top down to the floor of the church, which was above 200 feet; and that he had found, that a weight of four pounds being hung on a string of the bigness of a crow's quill, about $\frac{3}{4}$ of the pendulum remained steady, the rest making a single vibration in 6 seconds.[1]

Experiments Ordered.

It was ordered, that this experiment be repeated; and the Torricellian experiment, together with that of weighing, and of the celerity of descending bodies, be likewise made in the same place.

Petrifications.

There was read a paper of Mr. HOOKE's concerning petrifications, designed by him as a part of his microscopical book, then in the press. The Society approved of the modesty used in his assertions, but advised him to omit what he had delivered concerning the ends of such petrifications.

Instrument to Measure Seconds.

Dr. WILKINS mentioned, that Mr. HOOKE having a way to discover a second-minute of time by a sun-dial or the stars, to be performed by a certain instrument, which discovery he looked upon as greatly conducing to the finding of the universal measure;

[1] Mr. HOOKE's own account of these experiments in a letter to Mr. BOYLE, dated August 25, 1664, and printed among Mr. BOYLE's Works, vol. v, p. 534, is as follows: 'I have since your departure been on the top of Paul's steeple, in order to make several experiments, which will be prosecuted this week. But it being the first time I had been there, I could not be so well provided with an apparatus as I found was requisite, and therefore I was fain to return with only making some observations. One was, that a pendulum of the length of one hundred and eighty feet did perform each single vibration in no less time than six whole seconds; so that in a turn and return of the pendulum, the half-second pendulum was several times observed to give twenty-four strokes or vibrations. Another was, that this long pendulum would sometimes vibrate very strangely, which was thus: The greatest part of the line, by guess about six score feet of the upper part of it, would hang directly perpendicular, and only the lower part vibrate; at what time the vibrations would be much quicker, and this though there was a weight of lead hung at the end of the string of above four-pound weight. In another place of the Tower, where I had very clear perpendicular descent, I with the plumb-line found the perpendicular height of it two hundred and four feet very near, which is about sixty feet higher than it was usually reported to be. In which place I shall, with some other company, this week try the velocity of the descent of falling bodies, the Torricellian experiment, and several experiments about pendulums and weighing.' (Reprinted p. 190–1.)

it was ordered, that the instrument should be made for that purpose.

Aug. 25.

LETTER FROM HOOKE TO BOYLE.

Aug. 25, 1664.

Sir,

I hope this will find you safe returned to *Oxford* after your Western journey, which I understood you intended upon Thursday last to begin, or else I had before this sent the paper you gave me charge of; but being unable to do it time enough the last week, by reason I could not speak with my landlord, I have delayed it till the latter end of this, as supposing your return to *Oxford* could not be sooner. I have likewise here enclosed an Irish letter, which I received from my lady, and one from Mr. OLDENBURG, which he gave me this afternoon. I have since your departure been on the top of *Paul*'s steeple, in order to make several experiments, which will be prosecuted this week; but it being the first time I had been there, I could not be so well provided with an apparatus as I found was requisite; and therefore I was fain to return with only making some observations. One was, that a pendulum of the length of one hundred and eighty foot did perform each single vibration in no less time than six whole seconds; so that in a turn and return of the pendulum, the half second pendulum was several times observed to give twenty four strokes or vibrations. Another was, that this long pendulum would sometimes vibrate very strangely, which was thus. The greatest part of the line, by guess about six score foot of the upper part of it, would hang directly perpendicular, and only the lower part vibrate, at what time the vibrations would be much quicker, and this though there was a weight of lead hung at the end of the string of above four pound weight. In another place of the Tower, where I had very clear perpendicular descent, I with a plum-line found the perpendicular height of it two hundred and four foot very near, which is about sixty foot higher than it was usually reported to be. In which place I shall, with some other company, this week try the velocity of the descent of the falling bodies, the Torricellian experiment, and several experiments about pendulums, and weighing. I have since the last week almost

brought my treble writing instrument to be practicable, insomuch, that I hope to make it as easy to write three copies as one. I have made several trials of it, and have writ three sides together very well, but yet I hope to make it better. We yesterday made several odd experiments about the velocity and strength of a bullet shot out of a carbine, whereof some circumstances will certainly seem very odd: one of which was, that the bullet pierced through a board three inches thick, and yet broke not a very small weak piece of white thread, that held that barred against the force of the bullet: a second was, that though two of these small threads were tied across the nose of the piece, so as one would have thought it impossible, that the powder should have been discharged without breaking those threads; yet, notwithstanding, both the powder and bullet were discharged out of it, without doing the thread any other harm, than only a little singing it, which made me a little reflect upon the strange effects I had observed in thunder and lightning. And this puts me in mind of an excellent account we had of a prodigious storm, that lately happened in *Italy*, between *Venice* and *Padua*, which I should have added, but that I suppose Mr. O. has given you a copy of the letter. My lady I understand does to morrow intend to go towards *Leez*. I was among the booksellers this afternoon, but found nothing new.

Mr. Faithorne has promised me to make all possible speed with that you ordered him, but he does desire a little farther directions. Whilst I was writing this, Mr. Faithorne has sent me the sketch, which I have enclosed, to see whether you approve of the dress, the frame, and the bigness; what motto or writing you will have on the pedestal, and whether you will have any books, or mathematical, or chemical instruments, or such like, inserted in the corners, without the oval frame or what other alteration or additions you desire. It is almost ten o'clock, and therefore I hope you will excuse this scribbled paper, and the abruptness, wherein I am forced to subscribe myself,

Most honoured Sir,
your most humble, and
most faithful servant,
R. Hooke.

New Chariots.

Aug. 31. It was resolved, that the patent for the several new-fashioned chariots be drawn for Mr. HOOKE and his assistants.

Refraction by Water.

The experiment of measuring the refraction of common water was made with the new instrument prepared for that purpose; and the angle of inclination being 40 degrees, the angle of refraction was at first, when the hollow cylinder of the engine was not filled up to the wire, 14 degrees; but when the same was so filled, that it just covered the wire, it was 20.

It was ordered, that this experiment with common water be prosecuted, to see how it agreed with what had been of the same kind experimented by others; and that it be done at the several degrees of inclination from the perpendicular, and with several depths of waters: and that it should be tried afterwards with other liquors.

Pendulums and Falling Bodies.

Mr. OLDENBURG, in a letter written from London, Sept. 1, 1664, to Mr. BOYLE, and printed in the 5th volume, pp. 306, 307, of the works of the latter, mentions, that on the Monday preceding, 'a club of our philosophers went to Paul's, to make experiments of falling bodies and of pendulums. There were Sir ROBERT MORAY, Dr. WILKINS, Dr. GODDARD, Mr. PALMER, Mr. HILL, Mr. HOOKE; and some of them went to the top of the steeple, and let down a pendulum of 200 feet long, with an appendant weight of pounds, and found two vibrations thereof made in 15″. Time would not then give leave to proceed to the other experiments, that were designed, among which will also be the Torricellian; but they will be set upon within two or three days'.

Velocity of Bullets.

Sept. 7. It was ordered, that Dr. CHARLETON and Mr. HOOKE meet the Saturday following in the afternoon, to try the velocity of a bullet shot out of a gun.

Torricellian Experiment.

Mr. HOOKE gave an account, that the mercury in the Torricellian experiment made at St. Paul's was on the top of the steeple fallen about half an inch beneath the station thereof at the bottom of the church. It was ordered to be prosecuted on the Tuesday following, about nine in the morning.

Mr. HOOKE gives an account of this experiment in the following letter to Mr. BOYLE, dated Thursday, September 8, 1664, reprinted from Mr. BOYLE's Works, vol. v, p. 535.

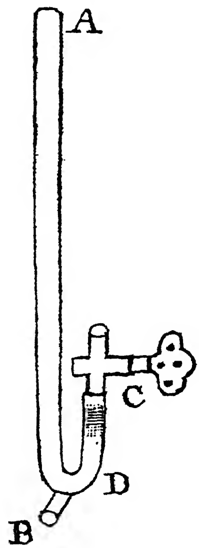
Sept. 8.

LETTER FROM HOOKE TO BOYLE.

Thursday-night, [Sept. 8, 1664.]

Most Honoured Sir,

I must in the first place return you my most humble acknowledgment for the honour and favour you have been pleased to oblige me with in your letter, which, to my power, I shall ever be



ready to express my sense of. As for the experiments, that I gave you an account of, that I intended to prosecute on the top of St. *Paul*'s, I have, by reason of some miscarriages, only proceeded thus far, that drawing up a mercurial tube, made after the form, and ordered according to the manner here described, [AB a glass pipe, about three feet long, whose end A was closed, and the other open at C, and bended in the manner of a syphon, as appears in the figure; into C was cemented a small stop-cock, to open and shut at pleasure: and just in the bending of the pipe, was drawn a small hole B, by which the whole instrument, when the cock was stopped, was filled carefully top-full with quicksilver; and then the hole was very well stopped with a small plaister of cement, spread on leather, and bound on when hot: then, by

inverting the tube, and opening the cock, the quicksilver would fall to its usual station; then, by turning the cock, this instrument became portable, and might easily be carried up and down, without any danger of losing the mercury, or admitting any air; for the mercury would not at all vibrate, which, without the cock, it was so very apt to do, that without a great deal of care and trouble, it could not be stirred or moved, but the air would break in, and get above the mercury,] I found the quicksilver to be at the top, full half an inch lower than it was at the bottom. The manner of making which experiment was thus. The steeple being without any kind of lofts, but having only here and there some rotten pieces of timber lying a-cross it; I caused a rope to be stretched quite cross the top, and fastned, in the midst of which I fixed a pully, through which I let down the string and weight to the bottom (for only in the very middle of the steeple was there a broad clear passage from top to bottom and to this I could not at the top approach within eighteen foot:) having thus let down the rope, those that were at the bottom hung on this mercurial tube (which I had exactly marked, and stopped, and set ready before I went up) a large weather-glass (which moved by the rarefaction and condensation of the air only, which I had likewise marked and stopped) and a sealed thermometer, which I had likewise marked. After these were drawn up, and, by a contrivance of another pully, I had drawn them to me, I found the thermometer, the glass being but thin, broken. The quicksilver, upon opening the cock, I found to fall very considerably, which since, upon measuring, I find $\frac{25}{48}$ of an inch: the weather-glass I found to be risen somewhat more than two inches: then closing them again, I caused them to be let down, and giving them charge not to let it quite down till I called to them from below, I went down myself, and found, upon opening the mercurial tube, that it rose exactly to its first station; as did also the weather-glass. I had designed to have tried many others then; but the night came so fast, that I could hardly see to get up again, and give order for the clearing of the lines. But I design, within a day or two, to make several other experiments. We have since the last made very few experiments worth your hearing, only trying the velocity of several small balls of bees-wax,

which descended in a glass pipe filled with water, and divided into inches, we found, by several trials, that it moved almost the whole length of 81 inches downwards, with very near an equal velocity, only somewhat accelerated towards the bottom, if the balls were very small; but if they were any thing big, we found them much slower towards the bottom; the reason of which was accidental, and would not have happened, had not the lower end of the tube been somewhat less than the top; but those small ones, whose motion the narrowness of the tube did not at all or very little stop, were observed for near twenty inches, to keep even pace with a half second pendulum, moving just an inch every vibration, but beyond twenty they grew swifter. I have consulted with Mr. FAITHORNE, who is ready to do any thing he shall be directed, and has desired me to contrive it, how it will be most convenient, and he will punctually follow directions. I have made a little sketch, which represents your first engine placed on a table, at some distance beyond the picture, which is discovered upon drawing a curtain. Now, if you think fit, I think it might be proper also to add, either by that, or in the corners A or B (where also you may have any other instruments, or any thing else added, if you think fit) your last emendation of the pneumatick engine. One word or two I beseech you of directions in this particular. I sent by the Wednesday's coach a small weather-glass, and Dr. HENSHAW's book, which is printed in *Ireland*, wherein he has mentioned you; and he has added a preface, and altered many things in his book. I hope, by the next post, to send you a farther account of my trials on *Paul*'s: in the mean time, and ever, I must remain, and in great haste subscribe myself,

Most Honoured Sir,
your most humble, and
most faithful servant,
ROB. HOOK.

Orion's Belt.

He related, that he had found the stars in Orion's belt, which Monsieur HUYGENS made but three, to be five.

It was ordered, that he having a thirty-six-foot glass, a tube should be made for it, upon the account of the Society, to make celestial observations with.

Measuring Seconds.

He was put in mind to prepare his instrument for measuring seconds of time by the sun or stars.

Weather-clock.

Sept. 14. It was ordered, that Mr. HOOKE should contrive a pendulum clock applicable to the observing of the changes of the weather, as well and as cheap as he could, for the use of the Society.

Measuring Seconds.

He was again put in mind to have ready his instrument for discovering second minutes by the sun, &c.

A Spot in one of the Belts of Jupiter observed 9 *May* 1664, *and published on March* 6, 1664–5.

The ingenious Mr. HOOK, did, some months since, intimate to a friend of his, that he had, with an excellent 12-foot telescope, observed, some days before he then spoke of it, (vid. on the 9th of May 1664, about 9 of the clock at night) a small spot in the biggest of the 3 obscurer *Belts* of *Jupiter*, and that observing it from time to time, he found that within 2 hours after the said Spot had moved from East to West about half the length of the diameter of *Jupiter*. *Philosophical Transactions*, i. p. 3.

A Method by which a glass of a small Plano-convex Sphere may be made to refract the Rayes of Light to a Focus of a far greater distance than is usual.

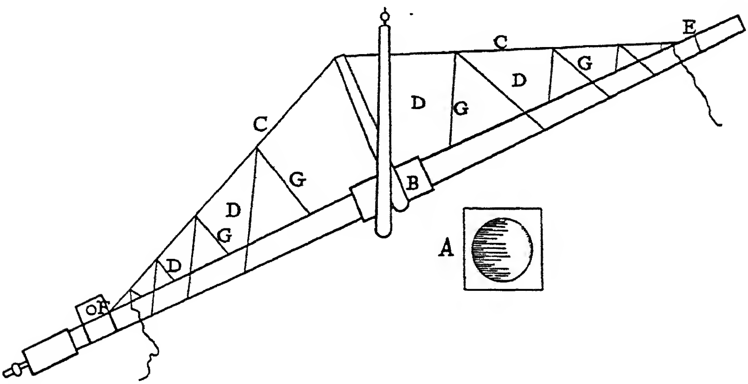
This is proposed by Mr. HOOK, in consequence of what was mentioned from him in Numb. 4, p. 67, of the Transactions.

Prepare two glasses, the one exactly flat on both sides, the other flat on the one side and convex on the other, of what sphere you please. Let the flat glass be a little broader than the other. Then let there be made a cell or ring of brass, very exactly turned, into which these two glasses may be so fastened with cement, that the plain surfaces of them may lye exactly parallel, and that the convex-side of the plano-convex-glass may lye inward, but so as not to touch the flat of the other glass. These being cemented into the ring very closely about the edges, by a small hole in the side of the brass-ring or cell, fill the interposed space between

these two with Water, Oyl of Turpentine, Spirit of Wine, Saline Liquors etc., then stop the hole with a screw and according to the differing refraction of the interposed liquors, so shall the Focus of this compound glass be longer or shorter.

But this I would only have look't upon as one instance of many (for there may be others) of the possibility of making a glass ground in a smaller sphere, to constitute a telescope of a much greater length: Though (not to raise too great expectation) I must add, That of Spherical object glasses, those are the best, which are made of the greatest sphere, and whose substance hath the greatest refraction.

Philosophical Transactions xii May 7. 1666.



Hooke's Method of Supporting Long Telescopes. *See* p. 478.
Figure to page 280.

Sept. 15.

LETTER FROM HOOKE TO BOYLE.

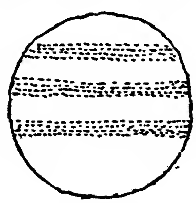
Gresham-College, Sept. 15, 1664.

Most Honoured Sir,

I received the honour of your letter, and shall endeavour to see your desires therein most punctually performed. As for the experiments on *Paul*'s, I have, since my last, made several other trials, which, I suppose, will not be unwelcome to you. Upon Tuesday, the lord Br. Sir R. M. and myself, were again at the

same place, and examined the vibrations of a pendulum of two hundred feet long: the line was a treble hard twist, one about the bigness of a very small goose-quill; the weight of it somewhat more than half a pound; at the lower end of this was hung a weight of lead of 28 pound averdupois; this we found, when each vibration was about 12 or 14 feet, to make one single vibration in 7 seconds and almost an half; that is, we found it to make 13 vibrations in 100 seconds pretty exactly; this we repeated several times, and found the same; then we suffered it to vibrate not above a foot, and we found them somewhat quicker; that is, 13 vibrations in 98 seconds. After this, we tried the same experiment, with a small wire about a 32 part of an inch in diameter, to which we hung the same weight, and found the vibrations very much the same, but somewhat swifter and longer. This we tried, both with longer and shorter vibrations, and found them to correspond with the former. On Wednesday we made farther trials at the same place, and that was with a very curious beam we brought two weights to an equilibrium at the top of the tower, the one was a 15 pound weight of brass, the other, that counterpoised it, was a company of smaller brass-weights tied in a small canvass bag together with the former small line, by which, after we had hung the beam over the very middle of the steeple, we let down the bag of weights to the bottom, and with long adjustening we found, that the counterpoising bag and string was grown lighter by a drachm. And this was very observable, that though the weight hung at that distance, and though, by some misfortune, the cock of the beam was missing, yet was the beam so tender, that a very small weight, as some very few grains, would very sensibly turn it, and, when brought to an equilibrium, the beam would vibrate, as if it only had a pair of short scales hanging to it. The cause of this phænomenon, *viz*. why the bag, that was let to the bottom, was found lighter, was judged to proceed from the density of the air at the bottom, which I acquainted you with, as I think, in the last letter: but we repeated the Torricellian experiment since, and found the difference some very small matter less than half an inch. But our weather-glasses again failed us, as did also our instrument for the velocity of falling bodies: yet some we made, but those so imperfect, that

I shall not, till we make them more accurate, trouble you with an account of them; nor of some other attempts, till I have farther perfected them. We made, on Wednesday, a very considerable experiment with powder; for inclosing only six penny-weight of P. Rupert's powder in one of our cylinders (the fashion whereof you, I doubt not, do well remember) and having very firmly screwed it up, it was fired by a small touch-hole, no bigger than a pin's head, which was drilled through the side of it: the effect was, that it broke the cylinder (which was every where very sound, and made of very tough iron, and, in the thinnest place, where it broke, was above half an inch, and in some near three quarters thick, so that I can hardly think the weight of 100 tun hung at it, would have been able to have pulled so much iron in sunder point blank) in four (if not more) pieces, and that in such places, where there was no beginning of a crack, with a most hideous crack and noise, like a small field-piece of ordnance: the side in which the touch-hole was made, we found intire; nor was that hole any thing widened by the eruption of the fire. We shall yet again make some more trials of it before we leave it, that so we may bring it to some certainty and theory. I begin now to make use of a 36 feet glass, and hope shortly to make some observations, which I hope may be worth your knowledge, the Society having very freely and willingly furnished me with tubes, according to my directions; as also with an exact time-keeper, which, I have some reason to believe, shall not be much excelled by any whatever. But these are not yet completed. In the mean time, I find very much is to be discovered with these long glasses, which none of the shorter I have yet seen would help one in; and this both in the moon, and the other planets;



and, looking this night on Jupiter, I found its form somewhat of this in the margin; of which I never saw it before, but only in Mr. Reeve's threescore feet glass some-while since. But I have

already, I fear, given you too much trouble with this tedious scribble; and therefore shall not, at present, add thereunto, by relating my designs and intentions, whereof I may more seasonably hereafter inform you, when experiment has been made; it being my design to acquaint you chiefly with matter of fact: and this method I am sure I shall not break, when I assure you, that I am,

Most Honoured Sir,
your most faithful, and
most humble servant,
R. HOOKE.

Sept. 15.

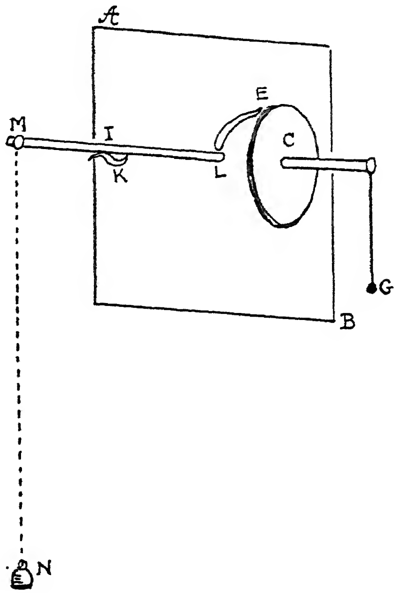
LETTER FROM W. CROONE TO DR. HENRY POWER.

Sir. I am commanded by our society to send you the enclosed paper, what the designe of it is you will quickly perceive by reading it, I conceive it will be an enquiry of good importance. Wee are now much engaged in the theory and experiments of the descent of body's and theire weight in several mediums; when anything is finisht I shall lett you know it, and here I shall adde another way, wich I think will serve to discover the thickness of the medium in the pitts, and how farr that has an influence upon the alteration of the weight of heavy body's: That is by enquireing the exact time in wich a body descends a certain space in one of your pitts, and an equall space above ground in the free aire. If you have noe place high enough above grounde, please to finde the exact time of descent in one of your pitts not exceeding 204 foot in depth, or from some part of it of that depth or less and wee can trye it here in the open aire, from the top of St. Pauls church, wich is just 204 foot high. It may bee done thus by a pendulum (as Mr. HOOKE who remembers his service to you) has contrived. If you cannot understand my rude description, you may designe a better yourselfe. To a piece of wood A B is fastened a wheele C, axis F to wich is fastened a small wire G (strikeing seconds) soe as the pendulum beeing putt in motion the wheele C moves alsoe, a little above it is fastened a spring E with a little latch at L, so that another latch of smalle iron M L meets with it, when it is pulled up from the wheele C. This small iron M L moves about a center in I and may have another back spring (if you please at K) under it, to keepe it in at the latch in L, to this iron at M is fastened a string as long as your body is to move, as M N to wich must bee fastened the descending body N. At the instant you lett downe the body from M the pendulum must bee putt in motion, and one appointed to tell the vibrations, as soon as it descends to N, it pulls downe

the part of the iron M I. and raises I L. So the latch of L is disengaged from the spring E, wich clapps immediatly upon the wheele C, and soe stops the pendulum. Mr. Hook's books of microscopicall observations with all the cutts will be out next post.

Yr humble servant
WILL CROONE.

Sept. 15, 1664. Leaden Hall streete.



Endorsed. Mr. Hooke's instrument for finding the exact time of descent for grave bodyes, which is explicated in the foregoing letter. [MS. Addit. 6193–4.]

The St. Paul's Experiments.

Sept. 21. The President acquainted the Society, that the experiment of weighing having been repeated upon the top of St. Paul's steeple, did not succeed this day as before, but that rather the lower weight somewhat preponderated; the cause of which difference was attributed to the windiness of the weather. It was ordered, that the President and Sir Robert Moray should desire the use of the King's statera for this experiment, and therewith weigh both the bodies above and below: and that the committee for this and the other experiment of the celerity of

falling bodies, should meet again on the Monday following, about eleven in the morning, at St. PAUL'S.

Wheal-worm.

That Mr. HOOKE give a draft of the ciron or wheal-worm, as it appears in a microscope.

Subscriptions Due.

Oct. 5. It was ordered, that Mr. HILL, the treasurer, speedily take care, that the arrears of the Society be collected; as also those of the subscribers for Mr. HOOKE; and that in the meantime he pay Mr. HOOKE both what he had received already from the said subscribers, and, as soon as conveniently he could, what should yet remain due to him; the whole being 80*l.* *per annum.*

Cutlerian Oration.

That Mr. HOOKE prepare an oration upon the account of Sir JOHN CUTLER'S founding of a mechanical lecture; and that, between that and the next meeting, he think upon a method to proceed by in his lecture, which, upon the Council's approbation, he might give a hint of in the said oration.

Refraction.

The experiments of the refraction of common water and spirit of wine were made; in the former of which, the angle of inclination being 30°, that of refraction was 41°, 35′; and in the latter, the angle of inclination remaining the same, that of refraction was 42°, 45′. So that the refraction of spirit of wine was greater by 1°, 10′, than that of the water.

Velocity of Bullet.

Dr. CHARLETON and Mr. HOOKE reported of the experiment, which they had made of the velocity of a bullet, shot out of a musket, that, as near as they could observe, the bullet being discharged with Prince RUPERT'S powder, went above six score yards in half a second. It was ordered to be prosecuted with more exactness.

Oct. 6.

LETTER FROM HOOKE TO BOYLE.[1]

[Oct. 6, 1664.]

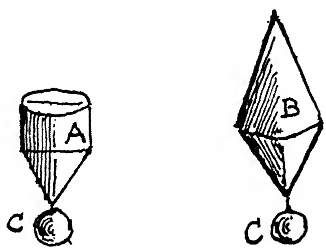
Most honoured Sir,

I have forborn all this time to give you the trouble of one of my scribbles, that I might have been able to have made it some-

[1] Mr. HOOKE'S letter to Mr. BOYLE of October 6, 1664, is printed in Mr. BOYLE'S Works, vol. v, p. 537.

what the less troublesom, by giving you an account of some further trials made on Paul's. But such have been the disappointments, from winds, and rains, and divers other accidents, that we have not as yet made any further proceeding in that business. The magnetical experiments also which you were pleased to propound should long ere this have been tried, had not the multitude of iron bars, wherewith all the top stone, and indeed all the stones of the steeple are tied together, wholly spoiled that design: and indeed I fear (the winter weather coming on so fast) we shall hardly make any more trials there before the next spring. Concerning hygroscopes I have lately made several trials, and among the rest I find, that there is no body so sensible of the changes of the air, as to driness and moisture, as the beard of the seed of *Geranium moscatum*, and of several other sorts of large cranes bill, a vegetable substance, that has not, that I know of, been taken notice of by any writer or other person whatsoever; and I have found it, if the seed be perfectly ripe before it be gathered, to be indeed the most proper body to make a hygroscope withal. I have also, since my settling at *Gresham* college, which has been now full five weeks, constantly observed the baroscopical index (the contrivance, I suppose, you may remember, which shews the small variations of the air) and have found it most certainly to predict rainy and cloudy weather, when it falls very low; and dry and clear weather, when it riseth very high, which if it continue to do, as I have hitherto observed it, I hope it will help us one step towards the raising a theorical pillar, or pyramid, from the top of which, when raised and ascended, we may be able to see the mutations of the weather at some distance before they approach us, and thereby being able to predict, and forewarn, many dangers may be prevented, and the good of mankind very much promoted. We have at the Society made lately several trials about the descent of variously figured bodies through the water, and amongst the rest (which are not yet brought to an exactness, and therefore I shall not till then trouble you with them) there was this very considerable discovery (for I do not find it was discovered, or so much as supposed before, but rather the clean contrary believed and builded on) that of two bodies of equal weight of the same wood, of the same shape,

as to that part, which did as it were cleave the water (which was conical, being a cone, whose basis was three inches diameter, and whose altitude was two) that body did descend the fastest through the water, which had the upper end flat, and that body the slowest, which had the hindmost end sharp. So that it seems, that the edge, which comes behind a square or flat sterned vessel, and is called the dead water, and which is much greater in such an one, than in a tapering sterned vessel, and is therefore commonly supposed to hinder and obstruct the swiftness of the vessel so much the more, does rather very much promote or accelerate its motion. The figures of the bodies were these in the margin, expressed by *A* and *B*, *A* representing the body, that went the fastest; and this did not seem to proceed from any other cause



than the flatness of the upper side of *A*, and the sharpness of that of *B*; the weight *C*, that sunk both the one and the other, being one and the same. We did yesterday likewise make a considerable experiment of refraction in the refracting engine (which I suppose you might see before you went for *Oxford*) for first we found the refraction of water (being able to measure it with accurateness to minutes) to be very near what has been hitherto assigned it, namely, we found the angle of incidence to be 41°. 35′. and the angle the refracted ray made with the perpendicular to be 30°. 00′. the signs of which angles (being 66371 and 50000, that is, as 398+to 300) are almost as 4 to 3. But all things remaining as they were, only removing the water out of the vessel, and putting in, instead of it, spirit of wine highly rectified (which we found would burn all away, and was by weight in proportion to the water near as 19 to 22) we found, that the refracted angle remaining the same of 30°. 00′. the angle of incidence was 42°. 45′. whose sines being 50000 and 67880, the proportion is somewhat more

than 3 to 4, namely, are 300 to 407; so that it seems the refraction of spirit of wine is greater than that of water. This experiment we tried upon Mr. OLDENBURG's being informed, that an experiment somewhat of this kind had been made at *Paris*. Both these experiments of the descent of bodies through the water, and of the various refractions of several sorts of liquors, I suppose we shall shortly prosecute more fully; there being many useful things on the true theory both of the one and the other. I am now engaged in a very great design, which I fear I shall find a very hard, difficult, and tedious task, and that is, the compiling a history of trades and manufactures; the person I formerly told you of, namely, Sir JOHN CUTLER, having very nobly and freely, without any compulsion or excitement, not only kept his word, but been better than it, sending me in yesterday a half year's salary before hand, as an earnest of his intention. The most I think I shall be able to do in this business this term (being engaged to read for doctor POPE) will be only to make a short speech, both in praise of Sir JOHN, my noble patron, and of the excellency and usefulness of the design it self, and of what method and course I shall take in it; and, by God's assistance, I shall endeavour to the utmost of my power, to go as far in it as I am able, being resolved wholly to apply my mind and endeavours to it. And if I can therein any way serve you, as I have great hopes I may, it will be esteemed a very great happiness by,

Most honoured Sir,
your most faithful
and most humble servant,
RO. HOOKE.

Huygens's Experiments.

Oct. 19. Sir ROBERT MORAY produced a letter of Monsieur HUYGENS to himself, which was read, containing, 1. A new observation of Jupiter, in whose disk the shadows of two of his satellites had been seen at Rome. 2. An account of watches with two springs so moved, that whilst the small weight is wound up by the great, it ceaseth not to have just the same force to make the balance-wheel, on which it immediately hangs, turn. 3. A speculation of his own, in which, by searching for simple pendulums, isochrone to triangles and other figures, he had met with considerable propositions, which he affirmed to conduce to the establishing of the universal measure. It was ordered, that

the several experiments specified in this letter should be tried, and Mr. HOOKE take care thereof.

Lens-grinding Instrument.

Mr. HOOKE was ordered to take care, that the instrument, contrived by him for grinding optic-glasses with more exactness and speed,[1] be forthwith made.

Rain After a Fall of the Barometer.

Mr. HOOKE intimated, that he had observed, that upon the fall of the mercury wet weather followed.

Oct. 21.

LETTER FROM HOOKE TO BOYLE.

Gresham College, Oct. 21, 1664.

Most honoured Sir,

I am extremely sorry, that I have not been able sooner to send down the ball and socket you desired; for such have been the disappointments of those I had bespoke it of, that no less than three have failed me, and I was fain to stand by a fellow most part of this day to direct him, and he has not yet quite finished it; but I hope to send it down to morrow morning, for Mr. REEVES (who understands these things, and I think he only, of all the turners I have met with) is at present in such a condition, that he can do nothing. Perhaps you may have heard of it: if not, in short, he has, between chance and anger, killed his wife, who died of a wound she received by a knife flung out of his hand, on Saturday last. The jury found it manslaughter, and he and all his goods are seized on; and it is thought it may go hard with him. As for the time of the conjunction of Mercury and Sol, there are so various calculations of it, according as they are made from these or other tables, that it is certainly the most safe way to watch for it two or three days before, and two or three days after the 25th of October. If it appear not sooner, we do here intend, God willing, to watch and make as diligent and accurate observations, as the season (which I am apt to think will be fair) and the apparatus we have will afford; whereof, God willing, I shall give you a more full account in my next. Here have not been many experiments since the last time I wrote worthy your notice: only

[1] Mr. HOOKE's letter to Mr. BOYLE dated October 21, 1664 (BOYLE's Works, vol. v, p. 538).

we did yesterday try the descent of bodies through water; the manner of which trials, though we have not yet brought them to any accurateness or method, may perhaps be not unacceptable to you. We took then a good large, round, thick glass, and by putting in very small shot, we brought it to an equilibrium with the water, in which we immersed it; and then taking the exact weight of it, we had thereby the weight of as much water as was equal to it in bulk. Of this weight we weighed five several parcels of shot, and four other parcels, that were equal each of them to a quarter only of this weight; then putting in one of these quarters, we found this bottle (which was hereby a quarter heavier than water) to descend eight foot of water in about 4″. 45‴. putting in a second, and so making it half heavier than water, it descendeth the same depth in 3″. 14‴. putting in a third, which made it $\frac{3}{4}$ heavier, its descent was in 2″. 45‴. by a fourth made as heavy again, or twice the weight of water, it descended in 2″. 14‴. by a whole parcel added, made thrice as heavy as water, it descended in 1″. 41‴. made four times as heavy, in 1″. 17‴. five times as heavy, in 1″. 10‴. five times and a half as heavy, which filled the glass with shot, in 1″. 6‴. I have not yet had time to cast up and see, what proportions these times keep to the preponderation of the descending globular glass; nor shall I trouble you with the repeating of these trials, which were found by the instrument for falling bodies not to differ more than some few thirds one from another. But by this way, when prosecuted, I hope we may be able to raise a true theory of the resistance of a fluid medium; but I have not as yet any time to spend on these things, and therefore should be very glad, if yourself, or Dr. Wallis, or Dr. Wren, would examine what might be done in that kind; and what observations shall be further made, I shall most faithfully give an account of. I am speedily going to make observations and tables of refraction by the instrument, which I find exceeding exact. And monsieur Zulichem's account, which he sends to Sir R. M. of their being able to see the satellites of Jupiter pass between that body and our eye, and to see the shadow those little moons make on the body of that earth; and to see those six several belts, and several other things, whereof I am apt to think Sir R. himself may have

acquainted you with, has at length made me set upon my way of making object glasses, which, you may remember, I did long since acquaint you with; for, certainly, if these be made with a mandrel only, without any tool, as the letter affirms, I hope I have reason to expect greater events from this, which must certainly be the most accurate way imaginable for making spherical glasses. What my success therein shall be, I shall be sure to acquaint you with. As concerning the baroscope; I find, that upon the fourth instant it was very low, and the wind was exceeding high; many of which instances I have not yet observed; but as soon as I can get a little time to make me a weather clock, and to set all my things in order for the enquiring into the causes of the changes of weather, which I fear will not be till after this term, I hope I shall be able to give you a better account. I meet with nothing now in *Paul*'s Church-yard, but two pamphlets, which, whether worth your sight, or not, I had not time enough to examine. I had herewithal enclosed also a small microscope, made with one single glass, which I find to magnify the object, and make it as clear, when conveniently placed, as one of Mr. REEVE's largest; but the glass was so small, that, in putting up, it was rubbed off and lost: but by the next I hope you may have as good a one sent you by,

Most honoured Sir,
your most affectionate
and most faithful
humble servant,
R. HOOKE.

Oct. 25. Conjunction of Sun and Mercury. [R. S. MS. No. 36.]

Mercury.

Oct. 26.[1] Dr. CROONE mentioned, that he had made observations of the sun from Tuesday noon till sunset, but found no appearance of Mercury.

[1] On this day the greatest part of the members were absent, being gone to Woolwich, together with the king and council and most of the court, to see the great ship St. Catharine launched; as appears from Mr. HOOKE's letter to Mr. BOYLE, October 29, 1664 (BOYLE's Works, vol. v, p. 540), and Mr. OLDENBURG's letter to that gentleman (*ibid.* p. 314). Mr. OLDENBURG himself going to Woolwich on that occasion.

Viper Dissected.

A viper was dissected,[1] and it was observed, that besides a row of small sharp teeth on either side of its upper and under jaw, the viper had also two fang-teeth in the upper jaw, which, upon being provoked, it would thrust and make stand out very far. These through the microscope appeared to be exceedingly sharp and very transparent, nor was there any visible sign of perforation in them; but that tooth on the right side only consisted of two small needle-teeth very sharp, transparent, and lying close together.

Oct. 29.

LETTER FROM HOOKE TO BOYLE.

[Oct. 29, 1664.]

Most honoured Sir,

I was not a little troubled, when upon Friday noon calling at the *Saracen's Head*, to see whether the ball and socket were gone (as the porter, that belongs to MOORE, had with all asseverations promised it should be by that morning's coach, for it was delivered to him before nine of the clock that morning) I found, that he had played the rogue, and kept it behind, intending to send it, as I suppose, by the next week's waggon, and this, though it were delivered to him with as great a charge as could be imagined. But as it has since fallen out, I hope there was not much harm done, Mercury having been too subtil for those, that laid spies for him, by slipping by the sun either in the night, or at least by one side of the disk of the sun; for to none of those, that endeavoured to find this conjunction here at *London*, has there been any glimpse of it, though upon Tuesday, as I imagined we should, we had very fair and clear weather. All which day my lord BR. Sir W. P., Mr. BALL, and myself, were very diligent in observations. I did not neither omit to observe the sun on Monday and Wednesday, as oft as I had opportunity of seeing it appear from between the clouds. Upon Wednesday last we had scarce any thing done, the most of the Society being gone to *Woolwich*, together with the king and council, and most part of the court, to see the great ship launched. I did notwithstanding dissect a viper, which gave some good discourses of poison, among the rest Dr. CROONE gave an account, that he had newly spoke with

[1] By Mr. HOOKE. See his letter to Mr. BOYLE of October 29, 1664. BOYLE's Works, vol. v, p. 540. Reprinted here, commencing on this page.

a person, that had a long time lived in the court of the king of *Macasser*, and had seen hundreds dispatched with those strange kind of poisons: and though very many European chirurgeons had tried to recover the persons, only very slightly hurt by the poisoned weapon, and though they had immediately, as soon as ever the person were hurt, cut out all the wounded part; yet within a very short space those poor wretches would fall down stone dead. But as concerning the fleshes being turned into a gelly, he could never have any certain knowledge of it, having never himself seen any such effect. Mr. POVEY affirmed further of our English vipers, that though many had thought the biting no way mortal, yet that not long since a gentleman, with whom he was intimately acquainted, was, by a bite in his hand from a provoked English viper, though all endeavours had been immediately used to prevent any ill symptoms, at length killed, after he had suffered an exceeding chilliness and deadness in that hand and arm for about a twelve-month, so as that he could not keep any heat in them, though wrapped with all imaginable care in furs and other warm clothes. Now though I was able to observe little in that day, yet I have since by examining the carcase found, that the teeth (though at first they appeared perfectly transparent, and seemingly solid) were all hollow, and filled with a liquor, or juice, which it is not unlikely may be their poison; for upon the drying of the teeth, I found, that that juice was also wasted, and by a chain of small bubbles, which then was visible enough through the microscope. I perceived the air had found the way into the cavity of the teeth. I fancied this viper had two fangs growing directly under each eye: that of them, which was under the right eye, though to the naked eye it appeared only one was discovered by the microscope, to consist of two small teeth much like cat's claws, that on the left side was only one single one. The contrivance for erecting and retracting, or sheathing the teeth, was very pretty, and like all other articular motions of the body very mechanical; for by their opening their mouths, two small jaw bones (as I may call them) which lay in the roof or upper part of their mouth, were made to thrust outwards and forwards, and thereby being joined as it were to the midst of the fangs; they erected the fangs, and there made them

unsheath or appear without a kind of lid or præputium, into which they did again slide and lye concealed, when those bones were drawn backward and inwards. These small bones had each of them seven or eight small teeth apiece: the viper had also two such small bones in the under-chop. Exactly like these Dr. affirms, the teeth of a rattle snake to be, but exceedingly bigger; and the hole in those teeth to be big enough to have a pin thrust into it. I did also make several tables of refractions from experiment, and find the hypothesis of sines to hold so great exactness, so that I think we need not much doubt, but that could we make elliptical glasses, much might be done in microscopes more than has been yet performed. I tried the refraction also of a very strong solution of common salt in water, and found the refraction greater than in common water. But which is more strange than any yet made, I found very clear oil of turpentine to have the greatest refraction of any body I have yet tried, though it be in specie much lighter than the spirit of wine or any body I know. What my calculations are, I have here transmitted in the following tables. I have also in the enclosed box put up one of the seeds of musk grass, which is the only one I have left, having given but one of the bills this year: this you will find under the small microscope. The glass of this microscope, though very small, is, I think, very good, which you may perceive, if, without stirring the small brush of hairs I have stuck on to it, you view them against the light of a candle, or of the window. I am now very busy about an engine for making long telescopes, and almost finished it; and hope by the next to have so far proceeded and succeeded in it, as that you may receive an account of it, which I hope will not be unacceptable to you, from,

Honoured Sir,
your most affectionate,
most faithful, and most
humble servant,
Ro. Hooke.

The observed angle in the liquor.	The observed angle in the air.	The sine of the observed angle in the liquor.	The sine of the observed angle in the air.	The hypothetical proportion of the sines of the angles of inclination in the air.	The angle answering the hypothetical sine.
		Common water.			
5.	6.39	8716	11407	11609	6.40
10.	13.19	17365	23033	23352	13.30
15.	20. 5	25882	34339	34474	20.10
20.	27. 4	34202	45503	45557	27. 6
25.	34.15	42262	56280	56294	34.15+
30.	41.45	50000	66588	66666	41.46−
35.	50.00	57358	76604	76400	49.50
40.	58.45	64279	85491	85419	58.40
45.	70.30	70711	94264	94387	70.42
		Brine.			
10.	13.35	17365	23486	23759	13.44+
20.	27.43	34202	46510	46756	27.52+
30.	43.10	50000	68412	68412	43.10
		Oil of turpentine.			
10.	14.45	17365	25460	25900	15.00+
20.	30. 5	34202	50126	50298	30.11+
30.	47.20	50000	73531	73531	47.20

Sir J. Cutler's Intention.

Nov. 2. Dr. WILKINS related, that Sir JOHN CUTLER had declared to him, that he was firm in his resolution to settle upon Mr. HOOKE 50*l.* *per annum* for such employment, as the Royal Society should put him upon.

Arrears.

It was ordered, that the operator employ himself diligently in collecting the arrears; and that the Treasurer direct him what persons he should collect from.

Refraction.

Mr. HOOKE'S account of the refractions of common water, salt-water, and oil of turpentine, was read; wherein he found the sinus of the angles of inclination to keep near the same proportion to the sinus of the angles of refraction. It was ordered, that this account be entered together with the experiments about the refraction of spirit of wine; and that these experiments be prosecuted with other liquors.

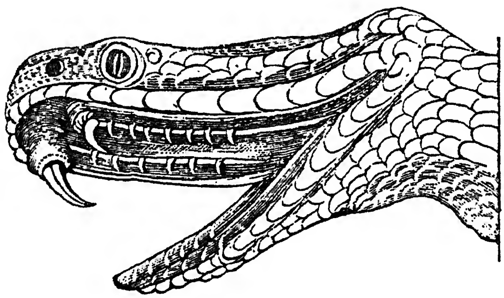
Teeth of Viper.

There was also read Mr. HOOKE'S fuller account of the teeth of a viper seen through the microscope transparent and hollow, together with other observations made of the internal parts of that animal; which account was ordered to be registered; as follows:

Examining the mouth of an English she-viper, I found, that in the upper part of the mouth, on either side, just under each eye, was placed a sharp round bended tooth, not unlike in shape to the claws of a cat. I observed likewise, that like those of a cat, they had a kind of sheath or skin, which, when they were moved forward, and thereby erected, slipped off from the tops of them towards the roots of them, leaving that part of the fang without it, very much shaped like a cat's claw, but somewhat smaller and slenderer: but when by another motion of the mouth they were drawn backwards, and so depressed, the skin was drawn over them, and perfectly covered them. That fang on the right side appeared plainly to consist of two teeth, shaped much alike, but the fang on the left side was only one single tooth. These being let alone, till pretty dry, I could plainly perceive to be hollow, by means of several chains of bubbles, which appeared within the transparent hollow teeth; though whilst the viper was alive, I could not perceive the least appearance of hollowness, but the teeth seemed perfectly transparent conical bodies. Besides these fangs, the viper had four rows of smaller teeth; two of which were in the upper and two in the nether chap. The bones, in which these short small teeth (with their very sharp transparent points directed inward) were fastened, were four small bones or jaws, which were not joined together before, but, as in a rhinoceros, each side was distinct, and one of them could be moved without stirring the other. When the viper opened its mouth to bite, these two jaw-bones were drawn forward, and thereby made not only the fangs to be erected and bare, but they themselves seemed to stand more out of the mouth, and the more clear to take hold of what the viper should snap at.

The position of these bones in the upper chap was much of the shape in the figure. The under chap had also two jaw-bones,

which were not joined together before, as is usual in other creatures, but distinct bones, like those in the upper chap. These lay nearer the tip or chin of the under chap; and about seven small teeth on each side were placed in the fore-part of it: near the top of this chap, between the two rows of teeth, was placed the epiglottis, or orifice of the *aspera arteria*. All the inward parts of this creature were as it were stretched into length and conveniently disposed the whole length of its body. The lungs were spun out into two long conical lobes, consisting of a great number of small transparent bladders, covered with a very pellucid skin: the bladder of gall was about three inches



TEETH IN UPPER CHAP OF VIPER.
The original sketch is in the Royal Society Hooke MS. Nos. 37, 38.

beyond the liver, which was very large, and stretched into a great length: the œsophagus, stomach, and the other guts lay in one continued straight line from its throat (which was exceeding wide, and capable of being stretched prodigiously) to its tail: the stomach seemed to be covered with a much thicker coat than the rest of the entrails: it had abundance of veins and arteries, that were spread over it: it had a great company of eggs, which were of several sizes, and placed all along the length of the belly. There were several other particulars very notable, which I have not yet sufficiently examined.

Respiration.

Mr. HOOKE proposed an experiment to be made upon a dog by displaying his whole thorax, to see how long, by blowing into his lungs, life might be preserved, and whether anything could be discovered concerning the mixture of the air with the blood in the lungs. It was ordered, that the experiment be made between that and the next meeting.

Dissection of Vipers and Frogs.

Dr. ENT was desired to dissect some vipers and frogs in a con-

venient season; and Dr. WILKINS and Mr. HOOKE to be present at the operation.

Lens-grinding Instrument.

Mr. HOOKE was ordered to endeavour to have his new instrument for grinding optic-glasses ready against the next meeting.

Cutlerian Lectures.

Nov. 9. Sir JOHN CUTLER having founded a lecture, and settled an annual stipend of fifty pounds upon Mr. HOOKE, as professor, during his life, entrusting the Society with direction and care thereof, was elected honorary member of the Society.

Refraction by Salad Oil.

An account was brought in by Mr. HOOKE of an experiment of refraction made with pure and clear salad-oil, which was found to have a much greater refraction than any liquor, which he had yet tried; the angle of refraction, that answered to an angle of inclination of 30 degrees, being found no less than 46 deg. 30′; and the angle of refraction, that answered to an angle of inclination of 20 deg. being 29 deg. 47′.

It was ordered, that this experiment be made before the Society at the next meeting, and that the instrument be fixed; as also, that other liquors, as several wines, aqua-fortis, aqua-regia, milk, &c. be tried, and that in several temperaments of heat and cold.

Respiration.

Mr. HOOKE acquainted the Society in writing with the success of the experiment made upon a dog cut open alive, and kept so for above a whole hour, by means of a pair of bellows and a pipe thrust into the wind-pipe of the dog; whereby the lungs being blown, the heart continued beating for a long while after the thorax and belly had been displayed, and a great part of the diaphragm cut away.

It was ordered, that this account be entered, and that the physicians of the Society consider against the next meeting, whether and how the experiment might be further improved.

Mr. HOOKE's account was as follows:

(3) *An account of a Dog dissected.* 1663.

"In prosecution of some inquiries into the nature of Respiration in several animals; a Dog was dissected, and by means of a pair of bellows, and a certain pipe thrust into the wind-pipe of the creature, the heart continued beating for a very long while after

all the thorax and belly had been opened, nay after the Diagphragme had been in great part cut away, and the Pericardium removed from the heart. And from several tryals made, it seemed very probable, that this motion might have been continued, as long almost as there was any blood left within the vessels of the dog: for the motion of the heart seemed very little changed after above an hours time from the first displaying the Thorax; though we found that upon removing the Bellows, the lungs would presently grow flaccid, and the heart begin to have convulsive motions; but upon removing the motion of the bellows, the heart recovered its former motion, and the convulsions ceased. Though I made a Ligature upon all the great vessels that went into the lower parts of its body, I could not find any alteration in the pulse of the heart: the circulation, it seems, being performed some other way. I could not perceive anything distinctly, whether the air did unite and mix with the blood; nor did in the least perceive the heart to swell upon the extension of the lungs: nor did the lungs seem to swell upon the contraction of the heart."

[Sprat, *History of the Royal Society*, 1667, p. 232.]

It being said, that air was felt to pass through the lungs, Dr. GODDARD conceived, that it might do so upon a stretch, and by more than ordinary force: but if it should do so in an animal unopened, and pass in a considerable quantity into his breast, and lodge there between it and the lungs, it might be a prejudice and hindrance to the motion of the lungs.

'Tin Ore'.

Mr. PALMER produced a very heavy mineral stone, conceived to be tin ore, which was referred to Mr. HOOKE to weigh it in water.

Nov. 10.

LETTER FROM HOOKE TO BOYLE.

Gresham College, Nov. 10, 1664.

Most honoured Sir,

I hope you received the ball and socket, together with two little pamphlets, and the beard of a musk grass seed, which I since inclosed in a scribble. I have not since that met with any thing worthy your knowledge; only this week I made two experiments,

which perhaps may not be unacceptable; the one was of refraction, wherein, in prosecution of the former experiments, I made some further trials upon sallet oil, and found the refraction of it to be much greater than that of any liquor I have yet tried; the refraction of thirty grains requiring no less than an angle of inclination in the air of 46°. 30′. and of twenty, an angle of inclination of 29°. 47′. So that the proportion of their sines is very near as 20 to 29+. or almost as 2 to 3. These experiments I am further prosecuting, to find out the refraction of all kinds of saline menstruums, of hot and cold water, of several kinds of oils; after that, I intend another instrument to find all the various refractions of crystal, glass, ice, horn, gums, and other transparent solid bodies; the refractions also of the parts of the eye, *&c.* Of each of which, as fast as I make them, I shall send you an account. The other experiment (which I shall hardly, I confess, make again, because it was cruel) was with a dog, which, by means of a pair of bellows, wherewith I filled his lungs, and suffered them to empty again, I was able to preserve alive as long as I could desire, after I had wholly opened the thorax, and cut off all the ribs, and opened the belly. Nay, I kept him alive above an hour after I had cut off the pericardium and the mediastinum, and had handled and turned his lungs and heart and all the other parts of its body, as I pleased. My design was to make some enquiries into the nature of respiration. But though I made some considerable discovery of the necessity of fresh air, and the motion of the lungs for the continuance of the animal life, yet I could not make the least discovery in this of what I longed for, which was, to see, if I could by any means discover a passage of the air out of the lungs into either the vessels or the heart; and I shall hardly be induced to make any further trials of this kind, because of the torture of the creature: but certainly the enquiry would be very noble, if we could any way find a way so to stupify the creature, as that it might not be sensible, which I fear there is hardly any opiate will perform. I observed this, that at any time, if the bellows were suffered to rest, and that by that means the reciprocal motion of the lungs were not continued, the animal would presently begin to die, the lungs falling flaccid, and the convulsive motions immediately seizing the heart and all the other parts of

its body; but upon the renewing the reciprocal motions of the lungs, the heart would beat again as regularly as before, and the convulsive motions of the limbs would cease. There are several, that are much awakened by this experiment, and, I find, intend to prosecute it much further; of which I hope I shall have a certain account. There was the last day of meeting, Nov. 2. a letter from monsieur ZULICHEM, wherein mention was made of a weaker glass made by the means of the rising and falling of a ball of wax in salt water. This I had then acquainted you with, but that I knew it would be no news, since I well remember, there were several experiments of this kind prosecuted by you at *Chelsea* three or four years since. There has nothing else occurred worthy your knowledge; which if there had, or that for the future any such shall, you shall thereof receive a punctual account from,

Most honoured Sir,

your most humble and

most faithful servant,

R. HOOKE.

I have not yet made any trial of my new engine, though it be now up, and was yesterday examined by my lord BR. Sir R. M. Sir PAUL N. and several others, and not one objection made against it, but approved by all. I hope within some few days to make some trial, how it will answer expectation. I forgot to acquaint you in my last, that it was Mr. RICHARD REEVES, that has killed his wife, but he now hopes, that he shall be able to get off, only it will cost him some money. The bookseller's shops afford nothing new.

Curator.

Nov. 16. It was resolved, that there shall be a Curator by office; and that Mr. HOOKE be proposed to the Society as such.

Dissection of Viper.

Mr. HOOKE undertook to dissect a viper, and to bring in his observations upon it at the next meeting.

Specific Gravity of 'Tin Ore'.

Mr. HOOKE reported, that the mineral stone, supposed to be a tin stone, produced by Mr. PALMER at the preceding meeting, being weighed in water, was found to be 6½ times as heavy as water.

Refraction.

There were read two or three experiments of refraction, viz. with cold, hot, and salt water, of which the hot and cold water were refracted alike, their angle of inclination being 30 deg. that of refraction 42 deg. *fere*. But the salt-water at the same angle of inclination had an angle of refraction of 44 deg. By which it seemed, that salt increases the refraction.

Mr. HOOKE proposed to find the difference of the refractions of air, and the vacuity of air in a glass.

He was ordered to bring in a list of experiments of refractions at the next meeting.

The experiments appointed for the next meeting were the refractions of oil of turpentine and other liquors.

Anatomical Experiment.

And Mr. HOOKE was ordered to give an account of his anatomical experiment.

Curatorship.

Nov. 23. It was ordered, that Mr. HOOKE standing for a curator's place, be this afternoon proposed candidate by Dr. WILKINS; as the doctor nominated him to the Council.

Micrographia Licensed.

That the President be desired to sign a licence for the printing of Mr. HOOKE's microscopical book;[1] And

That Mr. HOOKE give notice in the dedication of that work to the Society, that though they have licensed it, yet they own no theory, nor will be thought to do so: and that the several hypotheses and theories laid down by him therein, are not delivered as certainties, but as conjectures; and that he intends not at all to obtrude or expose them to the world as the opinion of the Society.[2]

[1] Mr. HOOKE, in a letter to Mr. BOYLE, dated at London November 24, 1664 (BOYLE's Works, vol. v, pp. 541, 542) mentions, that his microscopical observations had been printed off above a month; 'and the stay' *adds he*, 'that has retarded the publishing of them, has been the examination of them by several members of the society; and the preface, which will be large, and has been stayed very long in the hands of some, who were to read it'.

[2] Mr. HOOKE accordingly, in his dedication to the Royal Society inserted the following passage: 'The rules you have prescribed yourselves in your philosophical progress, do seem the best, that have ever yet been practised; and particularly that of avoiding dogmatizing, and the espousal of any hypothesis not sufficiently grounded and confirmed by experiments. This way seems the most excellent, and may preserve both philosophy and natural history from its former corruptions. In saying which I may seem to condemn my own course in this treatise, in which there may perhaps be

Refraction by Air.

Mr. HOOKE mentioned an instrument for measuring the refraction, which celestial bodies suffer in the air. He was ordered to bring in a scheme of it at the next meeting; as also, to take care, that his quadrant be made ready for discovering a second minute by a sundial or the stars.

Refraction.

That the experiments for refractions be continued, according to the list brought in by Mr. HOOKE.[1]

Curator.

Mr. HOOKE was, by Dr. WILKINS, proposed Curator by office to the Society; and the President acquainted them, that the Council had found it necessary to have a Curator; and that they would allow him, *pro tempore*, thirty pounds a year, the present revenue of the Society not being well able to bear a greater allowance; and that Mr. HOOKE was contented with that sum for the present, Sir JOHN CUTLER having settled upon him, during life, fifty pounds a year, upon the account of reading

some expressions, which may seem more positive than your prescriptions will permit. And though I desire to have them understood only as conjectures and queries (which your method does not altogether disallow) yet if even in those I have exceeded, it is fit, that I should declare, that it was not done by your directions.'

[1] These experiments were designed, as appears from a letter of Mr. OLDENBURG to Mr. BOYLE, dated at London, Nov. 24, 1664 (BOYLE'S Works, vol. v, p. 326) to examine the refraction answering to several degrees of inclination: To examine the comparative refraction of several liquors to common water; as, of all sorts of oils, made by expression or distillation; and to do this with several degrees of inclination: To examine how much the refractions of liquors are altered by mixing of several liquors together, that do, as it were, penetrate each other; as having examined the refraction of oil of vitriol and common water each of them apart, to mix them together, and find what is the compounded refraction, by mixing also of acid and sulphureous liquors, &c. To examine further the refraction of liquors, wherein hath been dissolved a determinate quantity of some kind of salt, as of sea-salt, common salt, saltpetre, alum, vitriol, alkali, tartar, &c. To examine the comparative refraction of a liquor, when a greater quantity of the same salt is dissolved in it, and when a less; as also, the refraction of a liquor, when two or more liquors have been dissolved in it; and the refraction of several liquors, wherein colours have been dissolved. Then to proceed to examine the refraction of all kinds of solid bodies, as diamonds, crystal, glass, ice, gummous and resinous substances, horn, arsenic, and all other transparent bodies; the refraction of several coloured glasses; and to find, by what means the refraction of glass may be augmented or diminished, and to examine also the refraction and structure of the several humours and parts of the eye; and to observe the refraction of the air of several densities; and lastly, to observe what would be the best figure and the best material to make dioptric lenses.

lectures of experimental philosophy: which addition had made him willing to accept, *pro tempore,* of thirty pounds a year from the Society for performing the office of a Curator.

The Society voted, that he should be dispensed with, as to the visitation of the Council.

Telescope for Measuring Seconds.

Mr. HOOKE mentioned a way of finding a second minute by a telescope, and was ordered to put this into practice.

Dissection of Viper.

He was ordered to make another dissection of a viper, and to do it in the presence of Dr. ENT and some other physicians of the Society, for the same purpose, for which he had lately done it; whereof he brought in an account in writing, which was read, and ordered to be registered, as follows:

In prosecution of some inquiries about respiration, I dissected a viper, and examining its lungs, I found the particulars very notable:

1. That having opened all the thorax and belly of the viper, from head to tail, I found, that it was able to extend a little, and as it were fill its lungs, notwithstanding a great part of them were open to the external air; the reason of which seems to be, that the part drying very fast, the film of the lung stuck fast to the *pleura,* or concave side of the ribs, and thereby, upon the opening of those ribs, the lungs were opened also: but this was accidental and not natural, the lungs at first seeming not to stick or adhere to them at all.

2. I found, that by thrusting a small pipe into the *aspera arteria,* and blowing in at it, I was able to distend the lungs to a very great bigness; and by making a ligature in the throat, about the *aspera arteria,* the air blown into them would continue to keep them extended, without finding any passage out.

3. By thus blowing, I found the lungs to be exceeding large, and to reach from the mouth almost to more than half the length of its body. The upper part next the throat looked like a company of bubbles in a parcel of froth; but the lower part looked very thin, clear, and transparent, exactly like a bladder, without any sign of diaphragms or partitions. This transparent cylindrical bladder seemed, when thus filled, as big about as the body of the viper, and was about some four or five inches long: upon pricking which with a point of a knife, the whole lungs subsided, and could not, by blowing it through the *aspera arteria,* be afterwards filled.

4. Upon opening the lungs, I found they were nothing but one continued bladder, from the throat to the middle of the belly; not seeming to have any kind of partition or parenchyma, but only to consist of a very thin skin or bladder: only the upper part of it looked almost like a net, but the under part consisted of a film, as clear as the bladder of a carp: and examining it with a microscope, I could not find any kind of vessel or muscle in it. But,

5. Upon examining the upper part with a microscope, I found, that the network, I formerly mentioned, was a contexture of veins and arteries, which were variously implicated and interwoven in the manner of a net; and I could plainly perceive all along the sides of those vessels several small chains of bubbles of air, which, whether they were separated from the blood to be discharged into the lungs, or rather whether they were separated from the air in the lungs to be mixed with the blood, I was not able by this dissection to discover.

6. It was notable also, that the *aspera arteria* reached from the mouth to more than half the length of the lungs; and though it were kept open by small bended cartilages as in other creatures, yet all these cartilages were so contrived, that the pipe seemed to be slit on one side from top to bottom: that is, each of them were bended somewhat more than half a circle, but none of them did perfectly meet, and make a circle: A particular providence certainly of nature.

Nov. 24.

LETTER FROM HOOKE TO BOYLE.

November 24, 1664.

Most honoured Sir,

Having received the honour of your commands by Dr. WREN, for procuring an instrument for refraction, whereby, as he told me, you designed to try the refraction of the humours of the eye; I did that very afternoon bespeak it; and I hope within a few days it will be ready to be conveyed to you. I have likewise procured out of Mr. OLDENBURG's hands some of the first sheets; and shall delineate as many of the instruments you mention, as I shall find convenient, or (if it be not too great a trouble to you) as you shall please to direct. I think it will be requisite also, because your descriptions will not refer to the particular figures and parts of them by the help of letters; that therefore it would not be amiss, if I add two or three words of explication of each

figure, much after the same manner, as the affections of the prism are noted in your book of Colours. The figures I think need not be large, and therefore it will be best to put them all into one copper plate; and so to print them, that they may be folded into, or displayed out of the book, as occasion serves. This puts me in mind to acquaint you also, that Mr. FAITHORNE has now at last promised me with all the asseverations imaginable, that he will not fail to finish your picture by the middle of the next week at furthest, and therefore I think I shall employ Mr. LOGGAN (who is an excellent graver also) that I may not take Mr. FAITHORNE off from finishing that plate. As for the microscopical observations, they have been printed off above this month; and the stay, that has retarded the publishing of them, has been the examination of them by several of the members of the Society; and the preface, which will be large, and has been stayed very long in the hands of some, who were to read it. I am very much troubled there is so great an expectation raised of that pamphlet, being very conscious, that there is nothing in it, that can answer that expectation; but such as it is, I hope I shall prevail with the printer to dispatch some time this or the next week. I have not yet brought the new way of grinding glasses to such perfection, as may deserve your knowledge, though I have not been wanting in endeavouring to go through with that business. And though I meet with many rubs, which bare speculation could not so easily inform me of, yet observing, that to be a fortune, which is almost inseparable from all attempts of any new thing, and out of the common road, I shall not at all slacken my diligence in prosecuting of it. The person you were pleased to mention, as having made the anatomical experiment on the heart of a dog, was at the Society the next day, and made a short report of it. I have been able to try very little in anatomy since my last; only I opened a viper, and found, that all the lungs were nothing but one continued bladder, which reached more than half the length of the body; that the upper part only of it was interwoven with an infinite company of veins and arteries; and that near those vessels I could discover several small vessels, which seemed filled with several chains of small bubbles. I have not yet been able experimentally to determine, what the use of them may be:

whether they were to be conjoined with the blood in the vessels, or with the open air, I cannot yet determine. I hear of nothing new in *Paul's* Church-yard, but only RICCIOLO's second part of his Almagestum is published and expected daily. There has nothing else occurred worthy your knowledge, which, as often as there does, an account thereof shall be speedily presented you by,

Most honoured Sir,
your most humble and
most faithful servant,
R. HOOKE.

This inclosed I received from Mr. EVELYN, who desires his most humble service to be presented to you.

Curatorship.

Dec. 7. Dr. WILKINS proposed Mr. HOOKE as candidate for a Curator's place.

It was ordered, that Mr. HOOKE be not examined as Curator.

Cutlerian Lectures.

It was ordered, that Sir WILLIAM PETTY, Dr. WILKINS, and Mr. GRAUNT draw up a form concerning the name and subject of Mr. HOOKE's lecture, and show it to Sir JOHN CUTLER, the founder thereof, to receive his thoughts upon it.

Pendulum.

Mr. HOOKE was ordered to attend the President on the Friday following, to adjust the pendulum to vibrate seconds.

Refraction.

Mr. HOOKE gave some account of the experiments of refraction made by him since the last meeting with solutions of vitriol, saltpetre, and alum, in water; where he had found the refraction of the solution of vitriol and saltpetre a little more, but that of alum somewhat less, than common water.

It was ordered, that at the next meeting the whole tube of the refracting instrument be filled with the liquor, the refraction of which was to be examined, and the glass be put at the lower end, exactly set at right angles to the tube; as also, that these experiments be made with several quantities of the liquor, and in vessels of several sizes; and that with liquors turbid and coloured as well as clear.

Experiments on Freezing.

A review being made of what experiments of cold were suggested the winter preceding, but left untried, it was found, that the following were then proposed, but not made: 1. To make a standard of heat and cold by observing the precise degree of cold, which freezeth common distilled water, and by marking thereupon the expansion of the liquor of the thermometer. 2. To include a loadstone in ice, in order to see what alteration it produces either in its attractive or directive virtue, or in both. 3. To reduce water into ice without blebs; and then to try, whether such ice, shaped into a cone, would serve for a burning-glass. 4. To put water into the receiver of the pneumatic engine, and having exhausted it, to let it freeze there, to see whether it becomes a clearer ice.

It was ordered, that these experiments should be made by Mr. HOOKE, when the weather serves.

Refraction by Air.

That he bring in the scheme for the instrument to measure the refraction, which the celestial bodies suffer in the air.

Quadrant to Measure Seconds.

That he have his quadrant made for discovering a second minute by the stars.

Huygens's Thermometer.

That he try at the next meeting Monsieur HUYGENS's way of a thermometer with a cane of salt-water and a glass-ball swimming in it.

Dec. 13.

LETTER FROM HOOKE TO BOYLE.

Dec. 13, 1664.

Most honoured Sir,

I am not only ashamed, that I have not sooner given you an account of what I promised in my last, but much more, that I am able as yet to say so little to the purpose; for though, when I last writ, I was promised, both by Mr. FAITHORNE and Mr. THOMPSON, that I should have those things which they had in their hands, finished within three or four days; and though I have often called upon them, and urged them all I could, I have not been able to get them done. I have lately observed many circumstances in the height of the mercurial cylinder, which do very much cross my former observations; for at this very time the quicksilver is as

high as I have a long time observed it, and I don't remember, that it has been higher: it has risen a little for these four or five days, and has continued so, notwithstanding the variety of winds, and the multitude of rain, that has lately fallen; and, I think, it rises a little yet, but it is but little. I have taken notice also of two or three other very odd particulars lately in it, which have crossed several other observations. The experiments we are now most busy about, are concerning the adjustening of the length of pendulums, thereby to settle a common standard for length; of which kind, Mr. ZULICHEM has sent over some very pretty theories; but upon very careful trial with several accurate and large pendulums, made with balls of lignum vitæ, some of which balls are six inches over, others no bigger than the head of a pin, or a small shot, and suspended by a very curious hair, which seems as likely a way as any to find out to what point of the globular body, hung at the end of a string, the length of such a pendulum is to be reckoned. Monsieur ZULICHEM says, it is $\frac{2}{5}$ parts of a third proportional below the center of the ball c, the first of which proportionals are, $ab+bc$ (that is, ac) and bc; namely, $ab+bc$, $bc :: bc$; $\frac{bc\,bc}{ab+bc}$, which we will suppose ce; $\frac{2}{5}$ of which taken below the centre gives d the point, to which the length of the pendulum ad is to be measured from a, the point of suspension. Sure it is, that this point is below c, the center of the body; but whether at d, I cannot positively yet affirm. The plate for your book was graven before I received your last of Mr. EVELYN's. I have only taken notice of seven instruments, which you in those sheets I looked on have described; and those I so put into one small plate, that they will fold out of the book, when there is occasion. This last of Mr. EVELYN I have given a small draught of also to the engraver, who is not an Englishman, but one, that I find a very good workman, and very punctual to his word; which was the reason I did not employ Mr. FAITHORNE, as you directed, he having so very often and often disappointed my expectation. I have since my last made an anatomy of a dog, and hope, that I have made a considerable new discovery; but this being the first time I have seen it, at least taken notice of it, I cannot, till further trial, positively

affirm any thing, which, as soon as ever I am assured of it, you shall thereof receive an account from,

Sir,

your most faithful, and

most humble servant,

R. HOOKE.

I hope, Sir, you will pardon this hasty scribble, for it was very near eleven a clock this night, before I could get from some company, met about the business of Sir J. CUTLER.

Subject of the Cutlerian Lectures.

Dec. 14. Sir WILLIAM PETTY made a report, that Sir JOHN CUTLER, intending a particular kindness to Mr. HOOKE in founding the new lecture, and bestowing upon him as reader fifty pounds *per annum* desired, that he might not be more burdened than the other readers of Gresham College are, but read only as many lectures in the vacations, as they do in term time: and further, that Sir JOHN CUTLER had intimated, that the management of this lecture by the Society, during Mr. HOOKE's life, should be a measure to him, to make it perpetual, or not.

Hereupon the subject and number of these lectures were much debated; and it was agreed upon, that the subject of them should be the *History of Nature and Art:* but with regard to the number of the lectures, it was not resolved upon, some urging, that Mr. HOOKE should be ordered to read once upon all the ordinary weekly meeting-days of the vacations, except those of the three months of August, September, and October, the greater part of half an hour, beginning about two of the clock: others pressing, that Mr. HOOKE might read but as many lectures as other professors do; and that the rest of the Wednesdays might be left to be endowed by some other benefactor for another philosophical professor.

Short Pendulums.

Mr. HOOKE suggested, that it would be best to make pendulums of the shortest length, considering, that a little variation in length makes a great alteration in time.

Universal Measure.

He produced a paper, containing some considerations of his about the most likely way of settling an universal measure; which was ordered to be registered, as follows:

It seems to me, that the most convenient substance of a pendulous body for this purpose should be some one simple or unmixed metal, such as refined gold, refined silver, clean copper,

tin, lead, or iron; for thereby all the parts of it will most likely be of an equal density and gravity: whereas if it should consist of two distinct substances, there might arise some inconveniency from the disproportionate gravities or densities of these two bodies, in respect of others the like; as if part of the pendulous body was made of iron, part of tin, the proportion between divers sorts of iron and divers sorts of tin being not always the same, might create some irregularity.

2. The most convenient shape seems to be some kind of prismatical body, by which I mean any kind of body, that may be supposed to be made up of an infinity of equal polygonal superficies or thin plates, placed directly one upon another; such as a triangle, square, rhombus, pentagon, hexagon, circle, &c. cut at right angles out of an equally thick plate of any very clean metal, and vibrating on any one corner or determinate part of it edgewise: for by this means it will be no matter how thick the plate be, whether the hundredth part of an inch, or a hundred inches.

3. As to the time, to which the vibration of such a pendulous body should be adjusted, the shortest time seems the best; first in respect of the make and substance of the pendulous body, being much more easily made of a small figure than of a larger: but next, and chiefly, in respect of the time; for the length of regular pendulous bodies being in a duplicate proportion to their times, the greater the length is, any small error in the time makes the error in the length the greater; and therefore, a pendulous body, that vibrates seconds, is much better than if we could have a pendulum to vibrate minutes; and one to vibrate every eighth part of a second is much better than one to vibrate seconds, or any longer time. And an error in one eight times shorter will be 64 times more easily distinguished than in the longer; that is, the shortening or lengthening the shorter pendulum $\frac{1}{64}$ of an inch will make as sensible a variation in the time, as lengthening or shortening the whole an inch.

But whether this will afford us an exact standard of the measure of space or extension, may seem dubious from these particulars:

First, from the nature of the motions of the heavens; for though it be generally presumed, that their motions are so constant, as to make their revolutions now, in the same space of time they ever have done, and ever will do: yet it is possible their revolutions may have been ten times as swift as now they are, and that they may in time be moved yet slower. For as we find here upon earth, the circular motion of a wheel, or top, or any the like turbinated body, which receives any kind of impediment from the medium, in which it is moved, or from any other external accident, is by degrees made much more slow, than

when it received its last impulse; so may the celestial bodies, since their first impulse they received at the creation, that set them in motion, be, by the impediment of the medium, through which they pass (though it seem the most fluid substance in the world) so impeded, that they may have lost very much of their first velocity: so that perhaps the men of the first age of the world, before the flood, might live no longer time than men do now, though they might see and number ten times more revolutions of the sun and heavens. Which if it should be so, the length of a pendulum to vibrate a second of time, reckoned by the revolution of the heavens at the beginning of the world, would have been found but a hundredth part of the length we find now fit for that purpose; and perhaps, if the motion of the heavens wax slower, the length of such a pendulum must be much more increased.

Secondly, from the nature of the principle, that moves the pendulum: for if the gravity of the earth be altered, either by time or place, all endeavours of making a standard this way will be in vain; for whensoever and wheresoever the gravity of the earth is stronger, there must the length of a second pendulum be much longer; and when and where it is weaker, there must it be shorter. The reasons, that may make each of these probable, seem to be these:

First, that all bodies and motions in the world seem to be subject to change, of which we may find instances, even in the very sun itself.

Next, we find, that the magnetical properties of the earth do in a very little time alter, and are sometimes more, sometimes less intense; and the line of directions and the point, to which it tends, seem to be varied with some irregular motions: if therefore the gravitation of the earth be magnetical, that may also alter.

Thirdly, if the gravity of the earth do any way depend upon the magnetic virtue of it, it is possible that property may be stronger toward the pole than about the equator (for we find the attractive virtue of the loadstone to be so); and if so, the standard by a pendulum will be uncertain because a second pendulum toward the poles will be much longer than near the equator.

Seconds Pendulum.

He gave also some account of what he had done at the Lord Viscount Brouncker's house in adjusting the pendulum to vibrate seconds, viz. that his lordship's pendulum vibrating just seconds, went a little quicker than those tried at Gresham College for seconds; and that the length of the pendulum for seconds at his lordship's was 3 feet $1\frac{2}{5}$ inches, and the ball of three inches diameter.

Refraction.

The experiment of trying the refraction of common water by filling the whole tube of the refracting instrument with it, was tried; and it was found, that it agreed with the usual way of trying the refraction of that liquor.

Refraction by Air.

Mr. Hooke produced the scheme for the instrument of measuring the refraction of celestial bodies; which was ordered to be registered.

Dec. 15.

Letter from Hooke to Boyle.[1]

Dec. 15, 1664.

Most honoured Sir,

This letter coming so late to the post-house on Tuesday night, was brought back to me, since which I have made farther trial of Mr. Zulichem's experiment; and both my lord Br., Sir R. M. and Dr. Wren, were judges and examiners of the experiment, and find, that the trials made with these pendulums, whose balls were of lignum vitæ, did not answer to Mr. Zulichem's rule, and therefore it is now much doubted of. We had yesterday in several parts of *England*, an account of the appearance of a very great comet in the south south-east, with a very long tail, extended towards the north-west; some say about ten yards long, some about two; but how much that is, is difficult to guess, unless we could see it, which I have done all this last night, but to little purpose, by reason of the thickness of the air. It has been seen in *Yorkshire*, and in *Cheshire*, and at *Portsmouth*, and several other parts of *England*. I this day got a sight of Mr. Faithorne's plate, and indeed he has done the face very carefully and well; and, I think, very like; but has not quite finished the plate. The other cuts are finished for your book of Cold; but Mr. Thompson has again disappointed me. Your anatomical experiments, read by Mr. Oldenburg, were very highly approved of by the whole Society. I cannot yet perfect my telescope glasses, though they do now very much more flatter me with hopes than at first; so that I shall not yet give over. It seems, by some papers of Mr. Oldenburg, that they have made in *France* object glasses of 250 palms, which is about 160 feet long, and make use of them without a tube.

[1] Printed in Mr. Boyle's Works, vol. v, p. 453.

Comet.

Dec. 21. There were read three several accounts of the comet lately seen.

Pearl-coloured Glass.

Mr. Hooke was ordered to show the Society such pearl coloured glass, as he had made formerly.

Circular Pendulums.

There were tried two wooden circular pendulums, one after another, hung by the edge; one of 18, the other of 9 inches diameter, with a small pendulum of $\frac{3}{4}$ the length of the diameters of those wooden circles; and it was found, that this small pendulum of the said length was isochrone to the vibrations of those wooden circles, according to Monsieur Huygens's rule.

Universal Measure.

Sir William Petty, Dr. Wilkins, and Mr. Hooke were desired to repeat by themselves in a very still room Monsieur Huygens's experiment for the universal measure; the experiment made twice in public having varied from his rule by $\frac{1}{10}$ the first time, and $\frac{1}{10}$ and $\frac{1}{20}$ the second time.

Seconds Pendulum and Short Pendulum.

Mr. Hooke was ordered again to attend the President at his house for adjusting the pendulum to vibrate seconds, it being doubted, whether the note of the preceding meeting about that particular was rightly taken.

He was likewise ordered to make a short pendulum, as best for keeping the time exactly.

Election of Curator.

Dec. 28. The Council approved of Mr. Hooke as Curator, in order to recommend him to the Society as such; and it was ordered, that the President be desired to recommend Mr. Hooke from the Council to the Society at their next meeting as Curator by office: And

That the amanuensis cause bills to be printed for summoning the Society on the 11th of January for the election of a Curator, and that the operator carry such bills abroad accordingly.

Circular Pendulum.

An experiment was made with a circular plane, hanging by a string of $17\frac{1}{4}$ inches, the radius of the circle being 9 inches; so that the distance from the centre to the point of suspension was $26\frac{1}{4}$ inches. Which being calculated by Mr. Hooke, according

to his rule, gave the distance from the centre of vibration to the point of suspension $27\frac{3}{4}$ inches, whereas it should have given $28\frac{3}{10}$ inches.

Seconds Pendulum.

Mr. HOOKE acquainted the Society, that he had been adjusting at the President's house the pendulum vibrating seconds; and that his lordship and he, though measuring by the same string, yet could not determine the exact length, because the string broke, which made them differ, his lordship finding 39 inches wanting $\frac{1}{20}$, but Mr. HOOKE $39\frac{1}{20}$ inches.

Comet.

Mr. HOOKE brought in his observations of the comet on December 23 in writing; whence he concluded, that this was the same star, that had appeared about a week before. He added, that it seemed to be a body, that was dissolved in the ether; and that the parts, that were dissolved, ascended from its body directly opposite to the sun, or from the gravitating centre of the planetary system, after the manner, in which smoke from a burning body ascends upwards from the centre of the earth. He exhibited also a scheme of the hypothesis, whereby he conceived, that all the irregular motions of the star towards the west, which it had hitherto been observed to make, might be explained by the motion of the earth, without ascribing any or but very little motion to the comet. He was ordered to continue his observations with all diligence and exactness, and to see, whether they and those of others would all agree with the said hypothesis, and to bring in an history of all in writing.

1664/5

Thermometer Applied to a Weather-cock.

Jan. 4. Mr. HOOKE showed the way of applying a thermometer to a weather-cock, by sealing up spirit of wine in a glass cane, with two pretty large heads, one of which was filled with spirit of wine, as was also the intermediate stem; the other not quite full, a space of air being left to give liberty for the expanding liquor. The cane thus filled was poised in the manner of the beam of a balance, and the operation of the heat and cold on it was, that heat expanding the liquor, made it pass through the stem out of the ball perfectly full, into the ball, wherein was left a space of air; so that heat made the air-ball descend, and cold on the contrary, condensing the liquor made it pass out of the air-ball into the full ball, and so made that to descend.

It was moved to consider, whether this instrument were sensible and nice enough.

Experiments on Cold.

It was desired, that those, who could, between that and the next meeting, make any experiments of cold, would make use of this weather, especially Dr. MERRET and Mr. HOOKE; the latter of whom was ordered particularly to prepare a thermometer, that might serve for a standard of heat and cold, by observing the degree of cold, which just freezes common distilled water, and by marking thereupon the expansion of the liquor in the thermometer.

Air Necessary for Combustion.

Mr. HOOKE made an experiment tending to show, as he conceived, that air is the universal dissolvent of all sulphureous bodies, and that this dissolution is fire; adding, that this was done by a nitrous substance inherent and mixed with the air. The experiment was, that he took a live coal, and put it under a glass vessel; whereupon the coal, after a very little time, went out; but then being taken out, and exposed to the free air, recovered its burning.

It being objected, that it was the agitation of the air driving the igneous particles into the combustible body, which made it burn and consume; Mr. HOOKE answered, that experiment would show, that a burning body, though agitated, would be extinguished, if it had not a free access of fresh air. He added, that a combustible substance, kept red-hot, even in a fire as hot as to melt copper, would not waste, but as soon as fresh air was admitted, burnt away and consumed.

An experiment was mentioned, to show, that a burning coal wanting fresh air would keep entire; but brought into new air would fall in pieces.

Jupiter's Moon.

Mr. HOOKE mentioned, that he had seen on the 19th of May 1664, about nine at night, a small spot in the biggest of the three black belts of JUPITER; and that observing it from time to time, he found, that within two hours after, the said spot had moved from east to west, about half the length of the diameter of JUPITER.

Hooke Proposed for Curatorship.

It was ordered, that the society be summoned against the Wednesday following, for the election of Mr. HOOKE as Curator by office to the society, who was by the President recommended from the council to the society.

Combustion.

Jan. 11. Mr. HOOKE made three experiments, conceived by

him to confirm his formerly proposed hypothesis about fire. The one was with a pipe having sulphur in it, sealed up hermetically, which, though made red-hot, yet burned not, but as soon as the air was admitted, burned away. The other was, that charcoal put into a pipe, and heated red-hot, did not at all consume or burn. The third was, that charcoal put into a crucible, covered with sand, was kept in a very great heat for about two hours, and being taken out after it had been suffered to stand to cool, was found scarce sensibly diminished.

It being objected, that the air in the vessels being superonerated with the steam of the wood was the cause of the not burning; it was answered by Mr. HOOKE, that an experiment should be made, to show, that though the air were not thus superonerated, yet the burning substance would go out, upon the account of wanting fresh air; and that this would be done by drawing the air out of the vessel, and making thereby the smoke fall down.

He proposed an experiment to be made at the next meeting by blowing forcibly with a certain contrivance the air included in a box, upon the coals, without making the coals burn.

Hooke Elected Curator.

Mr. HOOKE was elected Curator, by office, to the society, and that for perpetuity, with a salary of 30 l. a year *pro tempore*.

Boyle's Experimental History of Cold.

Mr. BOYLE brought in some printed copies of a part of his *Experimental History of Cold*, with a desire, that they might be recommended to the perusal of some of the society, to collect from thence such experiments, as are there proposed and wished to be made, or such as were by him made but imperfectly. The President took one of them, and another copy was delivered to Mr. HOOKE, upon condition to answer the end, for which they were presented by the author.

Standard Thermometer.

Mr. HOOKE produced his thermometrical standard for heat and cold, and gave an account how it had been made, viz. after the manner described in his *Micrographia*. This was looked upon, though not exact, yet better than the other ways hitherto used.

Blowing Engine.

It was ordered, that Mr. HOOKE consider of the engine [for blowing the fire in the brass works of Tivoli] to produce air by the fall of water.[1]

[1] The method was described by Walter Pope in a letter from Venice to Dr. Wilkins 'concerning the mines of mercury in Friuli, and a way of producing wind by the fall of Water.' *Phil. Trans.* ii. p. 21 Apr. 1665 and liv. p. 1080.

Longitude.

Jan. 18. Mr. HOOKE having made a proposition of giving the discovery of the longitude, as he had conceived it, to the society, it was ordered, that he should choose such persons to commit this business to, as he thought good, and make the experiment; that by such persons chosen, the council might be satisfied of the truth and practicableness of his invention, and proceed accordingly to take out a patent for him.

Combustion.

Mr. HOOKE was of opinion, that as air much rarefied, wherein the parts are enlarged, was found to make burning bodies go out, so condensed air would keep them longer alive.

Theory of Fire.

Mr. HOOKE desired, that some experiments might be suggested, that were thought not solvable by the hypothesis of fire proposed by him.

Eclipse of Moon.

Jan. 25. It was ordered, that Mr. HOOKE bring in his observations of the late eclipse of the moon on the 21st instant: And

Street's Astronomia Carolina.

That he peruse Mr. STREET'S appendix to his *Astronomia Carolina*, and give an account of it to the society.

The Comet.

Feb. 1. The President communicated a letter from the Earl of Sandwich containing some observations of the comet, which were referred to Dr. WREN and Mr. HOOKE.

Feb. 8. Some observations concerning the comet from Monsieur BEAUFORT, brought in by Sir ROBERT MORAY, were by order delivered to Mr. HOOKE, and to be communicated to Dr. WREN.

'Petrified Snow.'

Dr. HOARE produced a white body, brought from the Alps, said to be petrified snow; which Mr. HOOKE was desired to view in the microscope.

Combustion.

Feb. 15. Mr. HOOKE made an experiment with charcoal enclosed in a glass, to which nitre being put, and the hole suddenly stopped again, the fire revived, though no fresh air could get in.

Mr. BOYLE affirmed, that gunpowder burns very well in a receiver, out of which the air has been extracted.

He likewise affirmed, that tin mixed with nitre, and Mr. HOOKE added, that filings of iron mixed with it, would kindle it. It was ordered, that the experiments should be made.

It was ordered, that Mr. HOOKE make trial with a flaming body, and a body heated without flame, whether the heat and flame are preserved best in hot or cold air.

Mr. HOOKE made an experiment of gunpowder burning without air.

Weather-glass Experiment.

It was ordered, that a sealed weather-glass be made of thicker glass, to be enclosed in the compressing engine, to see, whether any alteration would be made in the liquor.

Lecture to be Printed.

Sir ROBERT MORAY moved, that Mr. HOOKE's lecture might be perfected and printed; which was assented to.

Resistance of Air.

It was ordered, that Mr. HOOKE's experiment of the resistance of air passing into small holes, be tried.

Weather-glass Experiment.

Feb. 22. There was tried an experiment with a common sealed weather-glass placed in the condensing engine, with a gauge in it; and the air being considerably compressed, the liquor in the thermometer was not found to rise sensibly.

Resistance of Air.

Another experiment was made to try what strength was requisite to force the air into the bores of small pipes filled with water; or how much of the pressure of the air is taken off by its ingress into smaller and smaller holes; and it was found, that the smaller holes required the greater force to drive in the air, and to force out the water.

Combustion of Nitre and Sulphur.

There was also made an experiment with nitre, put in an earthen crucible upon the fire; and sulphur being cast on the top of it, it gave a very bright vivid flame.

Telescope.

Mr. HOOKE was desired to think upon a fit place to make observations like those tried in Italy, with glasses made in England of about the same length with those of CAMPANI.

Removal of Spleen.

Mr. HOOKE gave an account of a dog, that died, after the spleen had been taken out; affirming, that he had seen a kind of glandule grown on to a piece of the spleen, that was left; and that the liver and caul were altogether putrefied.

New Quadrant.

Mr. HOOKE produced a new small quadrant contrived by himself, to make, by the means thereof, both celestial and terrestrial observations with more exactness than by the largest instruments, that had been hitherto publicly known. This quadrant was only of 17 inches radius, being by the contrivance of a small roller, that moved upon the limb of it, made so accurate, that each degree was actually distinguished into 60 minutes, each of which minutes being about one-third of an inch long, was actually divided into six parts, denoting every 10 seconds in a minute. The sights were likewise so contrived, though but short, as to be no less curious in distinguishing the parts of a minute in the visible object. The perpendicular also of the quadrant was so contrived, that, though it exceeded not much three feet in length, yet it could be adjusted, by the means of an index, so exactly, as if it were 60 feet long.

Combustion of Nitre and Sulphur.

Mar. 1. There was an experiment made to try, whether sulphur cast upon heated nitre would burn without air, by putting nitre into an iron crucible red-hot, and enclosing it in the rarefying engine, whence the air being well exhausted, (which appeared by the sucker's going down almost to the bottom) the sulphur, which thereupon by turning off the stop-cock was let fall upon the nitre, was seen to flame as freely, as if it had been in the open air.

Combustion.

The other experiment appointed for this day, of burning spirit of wine in the same engine, was referred to the next meeting; and Mr. HOOKE was ordered to devise more experiments to elucidate the nature of fire and burning.

Comet.

It was thought proper that Mr. HOOKE should extract out of his lecture a discourse upon the late comet, and fit it for the press, together with the necessary schemes.

Telescope.

The Italian account concerning the performances of the optic

glasses of CAMPANI upon certain characters being produced by Mr. OLDENBURG in English, it was ordered, that the President, Sir ROBERT MORAY, Col. LONG, Mr. HOOKE, and as many more as could conveniently, should meet on the Thursday following at night in Westminster Hall, and try some English glasses of Mr. REEVES's making of the same length upon the same characters, observing the circumstances prescribed in the paper concerning distance, light, &c.

March 6.

(4) *A Spot in one of the Belts of Jupiter* [observed 9 May 1664].

Reprinted on p. 196. *Phil. Trans.*, No. 1, March 6, 1664–5.

Liquors that generate 'Air'.

Mar. 8. Mr. HOOKE mentioned several liquors, that by their working upon one another would generate an air; viz. oil of tartar, and vitriol, spirit of wine and turpentine, &c.

Improved Chariot.

Col. BLOUNT proposed the improvement of the French chariot, by taking off the burden from the horse, by means of two small wheels before, retaining the long springy boards.

Mr. HOOKE suggested, that for the convenience of turning, the springs might be doubled, and so made shorter, whereby the rider would have ease, and the chariot turn in any street conveniently.

Pendulum Watches for Longitude.

Mar. 15. Mr. HOOKE remarked, that, in his opinion, no certainty could be had from pendulum watches for the longitudes, because, 1. They never hung perpendicular, and consequently the cheeks were false. 2. All kinds of motions upward and downward, (though it should be granted, that the watches hung in an exact perpendicular posture) would alter the vibrations of them. 3. Any lateral motion would produce yet a greater alteration.

The President observed, that these difficulties had been considered, and the matter put to experiment; which was to clear all.

In the meantime it was ordered, that the watches being brought ashore, some experiments should be made with them, by contriving up and down motions, and lateral ones, to see, what alterations they would cause in them.

Mr. HOOKE declared, that he intended to put his secret con-

cerning the longitude into the hands of the President, to be disposed of as his lordship should think fit.

Improvement of Artillery.

The President, the Earl of Northampton, Mr. Boyle, Sir Robert Moray, Sir William Petty, Mr. Henshaw, and Mr. Hooke, were appointed a committee, to consider of the improvement of artillery.

Mr. Hooke was ordered to draw up a series of experiments for the improving of artillery.

Valves in Wood.

He mentioned, that he had discovered valves in the pores of wood, and seen them cross the pores; which he was desired to show the society.

Barometer Records.

Dr. Goddard and Mr. Hooke were desired to consider of the barometrical observations made through the last year, and bring in an account thereof; and the former to be curator of making dissolutions of bodies.

Diving.

Mar. 22. It being moved by Mr. Hooke, that the air-boxes contrived for diving might be tried by the person bespoken by Mr. Pepys for that purpose; it was ordered, that this diver should be sent to Mr. Hooke, to be instructed by him concerning the use of the said boxes under water.

It was likewise ordered, that Mr. Hooke should procure glasses fit to see with under water, as far as the thickness or turbidness of the water would permit.

Respiration.

Mr. Hooke offered to consider of experiments relating to respiration for the next meeting.

[? *March* 1664–5]

Letter from Hooke to Oldenburg[1]

Sir,

I have not yet had any time to return M. Auz[out] an answer to his last printed return to what I formerly sent him, but in the mean time, according to your desire, I send you here a method, differing from any he has propounded, by which a glass of a small sphere, if plano-convex, may be made to refract the rays of light

[1] On March 15 and 22 Oldenburg read letters from Auzout to the R. S.

to a focus at a much greater distance than is usual. Prepare two glasses, the one exactly flat on both sides, the other flat on the one side and convex on the other, of what sphere you please; let the flat glass be a little broader than the other: then prepare a cell or ring of brass very exactly turned, into which these two glasses may be so fastened with cement that the plane surfaces of them may lie exactly parallel, and that the convex side of the plano-convex glass may lie inward, but so as not to touch the flat of the other glass. These being cemented into the ring very closely about the edges, by a small hole in the side of the brass ring or cell, fill the interposed space between these two with water, oil of turpentine, spirit of wine, saline liquors, &c. (then stop the hole with a screw,) and according to the differing refraction of the interposed liquors, so shall the focus of this compound glass be longer or shorter. This, when you have an opportunity, you may please to communicate, with my respects, to M. Auz[out]: and if he think fit to communicate his observations about the two last comets, I shall be very ready to return him an account of any thing of that kind, or of any other experiment which I have made.[1]

1665

Chariot.

Mar. 29. Mr. Hooke was desired to take notice of the pole of Prince Rupert's hunting chariot.

[1] The mention of Auzout's two comets probably refers to what was printed in the Phil. Trans. vol. I. pp. 3, 36.

This letter has neither signature nor address, but is in Hooke's hand-writing, and the following memorandum is written on the back of the paper by Oldenburg.

'So far the proposer of this method, who, in communicating it, does not so much maintain the practicableness of what is therein contained, as desire to give an instance (among many others) that some peculiar properties or qualities of natural things may enable those, that know them, to perform with ease such things, that to others seem either not feasible or not practical without great difficulty. But this I would have looked upon as one instance of many, (for there may be others,) of the possibility of making a glass, ground in a smaller sphere, to make a telescope of much greater length; though (not to raise expectation too high) I must add, that of spherical object-glasses those are the best, which are made of the greatest sphere, and whose substance has the greatest refraction.'

(Rigaud, *Correspondence*, p. 129.)

Red Spiders Poisonous.

It was ordered, that some red spiders or *Taints* should be procured by the operator, to try, whether they would kill a dog or cat.

April.

(5) *MICROGRAPHIA, or, Some Physiological Descriptions of Minute Bodies made by Magnifying Glasses, with observations and enquiries thereupon.* London, 1665.

[Reviews in *Phil. Trans.*, No. 2, p. 27, April 1665; *Journal des scavans*, December 1666. Reissued with a new title-page in 1667.]

This epoch-making work is too long, and includes too many new discoveries, to be adequately described here. Among the new scientific instruments described and figured in it are the Barometer; the Hygroscope made with the beard of a Wild Oat; an Engine for grinding Optical Lenses; and a Refractometer for Liquids; but the most important of all was the Microscope, by means of which cellular structure was seen and depicted for the first time in the history of the world.

After being piously preserved by the Royal Society[1] for many years Hooke's Microscope has been lost. A facsimile of its stand carefully made under the supervision of Mr. John Mayall and Sir Frank Crisp is now in the Lewis Evans Collection in the Old Ashmolean Museum at Oxford.

Rosemary.

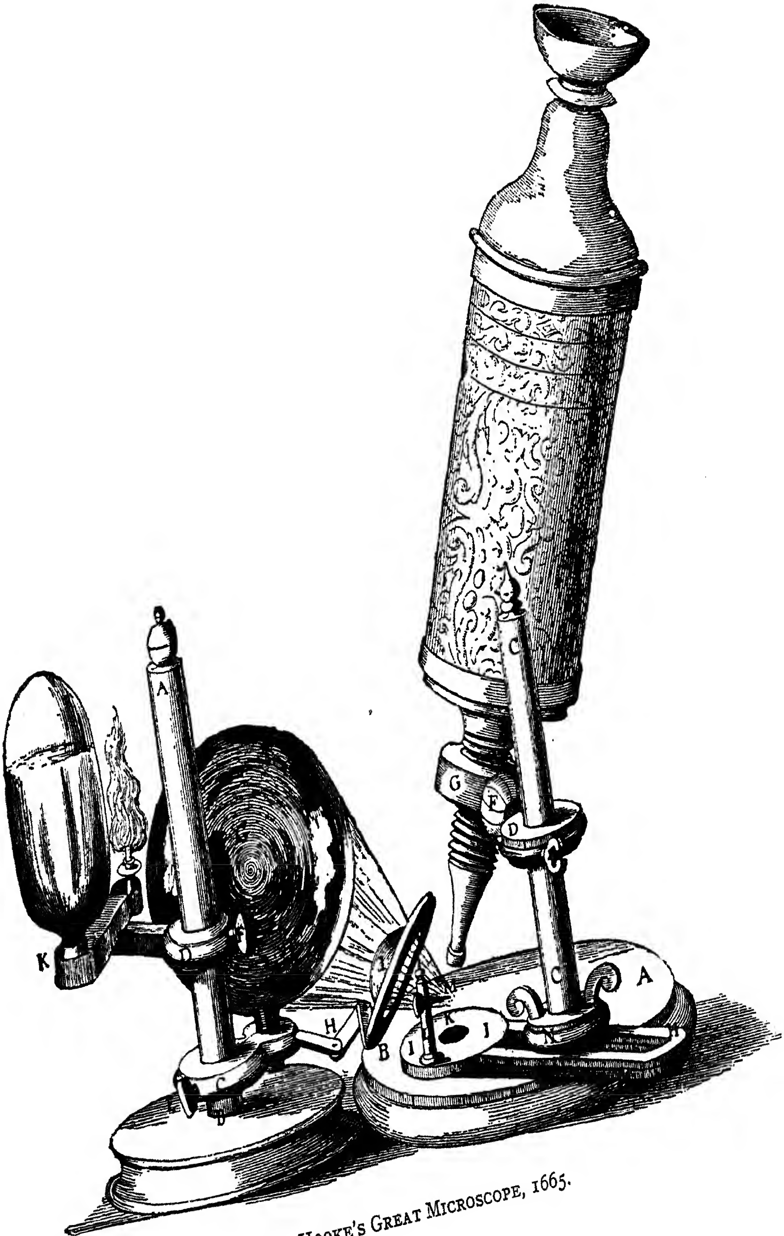
Apr. 12. Mr. Hooke affirmed, that a rosemary branch, cut from the root, will live by sprinkling common water upon it.

Experiments with Gases.

Mr. Hooke being called upon to give an account of one of the experiments at the last meeting relating to the air generated by aqua-fortis and the powder of oyster-shells, reported, that the greatest part of it was returned into liquor.

He was ordered to make at the next meeting the experiment of generating air with bottled ale, supposed to be wholesome to breathe in, which the air hitherto generated by aqua-fortis and distilled vinegar was not.

[1] Grew, *Catalogue.*



HOOKE'S GREAT MICROSCOPE, 1665.

It was moved, that the air produced by aqua-fortis and distilled vinegar might be given a dog to breathe in, to see the effects thereof.

Spiders.

The operator was appointed to try again the feeding of spiders upon one another, by shutting two or more of them up in a close glass. As also to put a house-spider among a good number of ants, and to see, whether it would be torn and eaten by them; Dr. WILKINS having related, that such a house-spider being put with a multitude of ants upon a barrel-head, the ants first ran away from the spider, but then returned, and tore it in pieces.

Chariots.

Mr. HOOKE was ordered to prosecute the model of his chariot with four springs and four wheels, tending to the ease of the rider.

It was likewise ordered, that the President, Sir ROBERT MORAY, Sir WILLIAM PETTY, Dr. WILKINS, Col. BLOUNT, and Mr. HOOKE should be desired to suggest experiments for improving chariots, and to bring them in to the mechanical committee, which was to meet on the Friday sevennight following, April 21, at the President's house.

Comet.

The account of the new comet, sent to Mr. HOWARD by his brother from Vienna was delivered to Mr. HOOKE, to compare it with other observations.

First Comet.

Apr. 19. Sir ANDREW KING'S paper with a scheme of the first comet, drawn by a Spanish Jesuit at Madrid, was delivered to Mr. HOOKE to compare it with the other observations; who was also appointed to take a copy of Dr. WREN'S scheme of this comet, and to return the original to the Doctor for further consideration.

'Air' from Ale.

The experiment of generating air with bottled ale, corked and tied fast about with an ox-bladder, was tried; but it yielded no air.

Comet.

Apr. 26. Mr. HOWARD produced some observations on the second comet, as they were sent to him by his brother from Vienna; which were recommended to the perusal of Mr. HOOKE.

Blount's Chariot.

It was ordered, that the committee formerly appointed, viz. the President, Sir ROBERT MORAY, Sir WILLIAM PETTY, Dr.

WILKINS, Col. BLOUNT, and Mr. HOOKE should be desired to meet at Col. BLOUNT's house at Writlemarsh, about Col. BLOUNT's model of a chariot with four springs, on the Monday following, and give an account of what they had done there at the next meeting of the society.

Comets.

May 17. Three accounts were brought in of the late comets; one by Dr. WILKINS concerning the first, sent out of New England; the other two by Mr. AERSKINE, concerning the latter, written from Prague and Liège: All which were ordered to be delivered to Dr. WREN and Mr. HOOKE.

Variation of Magnetic Needle.

It was ordered also, that on the Friday morning following, about nine, the variation of the needle should be observed in Whitehall garden, by the curators formerly appointed for that purpose; and that Mr. COLWALL be desired to speak to Mr. MARRE to be present, and furnish materials necessary for that observation.

Mr. HOOKE mentioned, that he had a pocket-needle, which would show the variation of the needle. He was desired, upon further consideration, to give a particular account of it to the society.

Refraction.

Mr. HOOKE was ordered to try some experiments of refraction by himself, and to acquaint the society at their next meeting with the success thereof.

May 24. Mr. HOOKE having acquainted the society, that he had found the refraction of oil of turpentine upon water to be the same with that of water alone, the experiment was made before the society, which verified the account given, viz. that in both these, the inclination being thirty degrees, the angle of refraction was 40° 43′. And it was conjectured by Mr. HOOKE, that the upper and under surfaces of the oil being parallel, was the cause of the non-alteration of the refraction, with more thickness of the oil of turpentine.

Caterpillars on Sallows.

There was read a letter to Mr. HOOKE from Dunkenhall in Lancashire, dated 16 May, 1665, concerning caterpillars, that seemed to be produced of the downy palms of sallows. It was ordered, that if the season were not past, Mr. HOOKE take care to make the observation himself.

Transfusion of Blood.

Dr. WILKINS, Mr. DANIEL COXE, Mr. THOMAS COXE, and

Mr. HOOKE were appointed to take care of injecting the blood of one dog into the vein of another; and Mr. THOMAS COXE was particularly desired to try the changing of dogs' skins.

Monstrous Colt.

Mr. BOYLE produced a monstrous head of a colt, put into spirit of wine, with a double eye in the midst of its forehead, having double eyelids, and double pupils. Mr. HOOKE was ordered to draw the picture of it, and then to dissect it.

Grinding Engine.

May 29. It was ordered, that Mr. HOOKE be urged to prosecute the grinding of glasses by his new engine.

Mr. HOOKE mentioned to the council, that he had a way of making a short object-glass draw as much longer, as should be desired.

Monstrous Colt.

May 31. The monstrous colt's head was opened, wherein both the eyes were found together in one place in the midst of the forehead, and two pupils therein, and but one optic nerve. Mr. HOOKE was appointed to give in writing a full description of all that was observable in this head, together with the scheme of the head.

This and other curiosities were committed to Mr. HOOKE for the repository.

Refraction.

The experiments of refraction were deferred till the next meeting; and Mr. HOOKE was ordered to have the vessel of the refracting engine made larger, in order to try several quantities of liquors.

Tobacco-oil.

The dog, who had the eight or nine drops of tobacco-oil injected at the last meeting, being inquired after, the operator affirmed, that he was well.

June 5.

(6) *Answer to M. Auzout's Considerations upon his* [Mr. Hooke's] *New Instrument for grinding of Optic Glasses.*

Phil. Trans., No. 4, pp. 64–9, June 5, 1665.

Air and Germination of Seed.

June 7. Mr. HOOKE reported, that he had sown some lettuce

seed upon earth in the open air; and at the same time upon other earth in a glass receiver, which was afterwards exhausted of air; that the seed exposed to the air was grown up an inch and a half high within eight days; but that in the exhausted receiver not at all: both which were produced and shown the society.

Whereupon it was ordered, that air should be let into the exhausted receiver, to see whether any of the seed would come up between this and the next meeting.

Variation of Magnetic Needle.

It was ordered also, that the next day, June 8, about five in the evening, the variation of the needle be observed in Whitehall by the same committee formerly appointed for it, viz. the President, Sir ROBERT MORAY, Sir PAUL NEILE, Dr. WREN, Mr. OLDENBURG, and Mr. HOOKE; and that Mr. MARRE and Mr. BOND have notice given them by the operator, to bring their needles and instruments to the said place.

Lifebelt.

Mr. HOOKE said it might be thought upon to contrive a way of making a girdle to be tied about a man to save him from sinking. He was ordered to think upon it himself.

Wheel to go over Land and Water.

He mentioned a certain wheel to go in both over land, and bogs and water.

It was objected, that in plain grounds such a contrivance would be of use, but in ascents useless; yet it was moved, that Mr. HOOKE should endeavour to have a wheel made for a trial.

Algebra Lecture.

June 10. On this day HOOKE delivered his first Lecture on Algebra.[1]

Grinding Engine.

June 14. There was read a letter of Monsieur HUYGENS to Sir ROBERT MORAY, dated at the Hague, May 29, 1665, N. S., expressing his apprehensions about the difficulty of making Mr. HOOKE's new grinding instrument to succeed.

New Sextant.

June 21. Mr. HOOKE produced a sextant contrived by himself, and explained the use and structure thereof, viz. that it was made after the manner of a pair of dividing compasses, there being two three-feet tubes opening upon a joint in the manner of

[1] The MS. is in the R. S. Collections, No. 39.

the legs of compasses, and a long straight screw moving in two motions, serving to take angles very exactly.

It was moved by Sir PAUL NEILE, that this instrument might be examined, to see whether it performed what it was intended for, by measuring some known distances with it: And it was ordered thereupon, that this should be done.

Maltese Fossils.

Mr. HOOKE produced some curiosities addressed to him by Mr. WILLIAM JUMPER, viz. certain tongues, and teeth, and eyes, called serpents'-tongues, &c. said to be found frequently at Malta, and knocked out of that rock only where St. PAUL suffered shipwreck. They were ordered to be put into the repository.

Flying.

Occasion being given to discourse of the art of flying, and Dr. WREN being desired to leave with the society what he had considered on this subject, promised to do so. He affirmed, that a man would be able so often to move the wings, as he could with double his own weight on his back ascend a pair of stairs built at an angle of 45 degrees.

Mr. HOOKE suggested, that it was not sufficient to have a theory for the descent of an expanded area perpendicularly downward, because the descent of an expanded area, moved edgewise horizontally in the air, was extremely different; in which way however all motion of flying must be performed.

Payment to Curator.

June 28. It was ordered, that the President be desired to sign the allowance to Mr. HOOKE as Curator to the society, though the sum exceed five pounds.

Hooke's Holiday Task.

The members of the society were then exhorted by the President to bear in mind the several tasks laid upon them, that they might give a good account of them at their return; and Mr. HOOKE was ordered to prosecute his chariot-wheels, watches, and glasses, during the recess.

The Plague.

July 8.

LETTER FROM HOOKE TO BOYLE.

Gresham-College, July 8, 1665.

Most Honoured Sir,

I did this last week send down by MOOR'S waggon a weather-glass poised upon its centers. I supposed it would be very easy

to get a frame made for it at *Oxford*, otherwise I would have sent one with it, but it would have much endangered the breaking of the thermometer, which it did once in our packing of it up; but I caused another to be made, which I think is very strong, and, I hope, very safely packed up. I doubt not, but that you have long before this heard of the adjourning of the Royal Society, and of the increase of the sickness, which rages much about that end of the town you left. I hear, several in the *Pell-mall* are infected, and one house almost emptied. It is not much spread as yet in the city, God be praised, though it be dangerously scattered. I cannot, from any information I can learn of it, judge what its cause should be, but it seems to proceed only from infection or contagion, and that not catched but by some near approach to some infected person, or stuff: nor can I at all imagine it to be in the air, though yet there is one thing, which is very differing from what is usual in other hot summers, and that is a very great scarcity of flies and insects. I know not whether it be universal, but it is here at *London* most manifest. I can hardly imagine, that there is a tenth part of what I have seen other years. We have made very few experiments since you were pleased to be present, but I hope, as soon as we can get all our implements to *Nonsuch*, wither Dr. WILKINS, Sir W. PETTY, and I, are to remove next week, I shall be able to give you an account of some considerable ones, we having designed to prosecute the business of motion through all kinds of mediums, of which kind Sir W. has made already many very good observations. We shall also take the operator along with us, so that I hope, we shall be able to prosecute experiments there as well almost as at *London*; and if there be any thing, that you shall desire to be tried concerning the resistance of fluid mediums, or any kind of experiments about weight or vegetation, or fire, or any other experiments, that we can meet with conveniencies for trial of them there; if you would be pleased to send a catalogue of them, I shall endeavour to see them very punctually done, and to give you a faithful account of them. I very much fear also, that we shall be forced against our wills to stay there long enough to try experiments of Cold, though I have some thoughts of removing to another place farther from *London*, where I have designed to try a large catalogue of experi-

ments, such as one cannot every where meet with an opportunity of doing; but the country people are now so exceeding timorous, that they will not admit any, unless one have been a considerable time absent from *London*. I was this day informed by one, that received a letter thence, that the plague rages so extremely in *Southampton*, that sometimes there die thirty in a night; and that has made *Portsmouth*, and the isle of *Wight* so fearful, that they will suffer none to enter. The founder has brought home the saucer stop-cock, which I sent about the case of the weather-glass. Mr. THOMPSON also has sent home the instrument for taking angles, and demands two and thirty shillings. It is not quite finished, but I intend to take it with me to *Nonsuch*, and there to make trial of it, and adjusten it. I shewed it the last meeting of the Society, which it was very much approved of; and I hope it will be the most exact instrument, that has been yet made. But I weary you with my impertinencies, and must therefore humbly beg your pardon, and make haste to subscribe myself,

Most honoured Sir,
your most humble, and
most faithful servant,
R. HOOKE.

Aug. 15.

LETTER FROM HOOKE TO BOYLE

Aug. 15, 1665.

Most honoured Sir,

I have not since the receiving of your letter, had the opportunity of sending to Mr. OLDENBURG, to learn from him the account of the experiment, which you were pleased to mention in it. I have longed very much to be satisfied concerning it, as believing it very considerable. I have made trial since I came hither, by weighing in the manner, as Dr. POWER pretends to have done, a brass weight both at the top, and let down to the bottom of a well about eighty foot deep, but contrary to what the doctor affirms. I find not the least part of a grain difference in a weight of half a pound between the top and bottom. And I desire to try that and several other experiments in a well of threescore fathom deep, without any water in it, which is very hard by us. One of

our quadrants does to admiration for taking angles, so that thereby we are able from hence to tell the true distance between *Paul's* and any other church or steeple in the city, that is here visible, within the quantity of twelve foot, which is more than is possible to be done by the most accurate instrument, or the most exact way of measuring distances. The other, which is yours, I hope within a day or two to perfect it, so as to go much beyond the other for exactness, of which I may give you an account as soon as I have tried. There happened lately a pretty odd accident: A very young and seemingly healthy gentlewoman by drinking the *Epsom* waters, and afterwards giving her young child (not yet much above a quarter old) suck, found, to her extreme sorrow, that though the waters did not at all work with her, yet that so wrought on the sucking child, that it fell into a most violent looseness and griping, which within three days killed it. I made last night also a pretty odd discovery of a new kind of shining animals, whose blood, or juices, did shine more bright than the tail of a glow-worm, when the candle was put out. I have nothing more to add, but that I am,

Most honoured Sir,
your most faithful, and
most humble servant,
R. HOOKE.

There is somewhat above thirty shillings due to Mr. THOMPSON. I have forgot the particular sum, but if I misremember not, it was thirty two shillings: but as for Mr. FAITHORNE, I never made any bargain for more than twelve pound, nor did he at first mention any more of me. If you have any further commands, you may send it thither by the post, I suppose, if not to be left for me at *Gresham* college, from whence I receive letters usually once a week. I am still at *Durdens*, my lord BERKLEY's house near *Epsom*, where Dr. W. only remains, Sir W. P. being gone to *Salisbury*. My service, I beseech you, Sir, to Mr. CROSSE and his lady, and to Dr. LOWER, if in *Oxford*.

Aug. 23.

Mr. OLDENBURGH'S *letter to* Dr. HOOK. *Concerning the plague then, and grass in sheep's and oxen's lungs.*[1]

Sir,

I cannot but commend you for being so careful of yourself in this dangerous time, as not to venture to come amongst us, especially when you find yourself any ways out of temper. The sickness grows still hotter here, though I find by all my own, and other men's observations, that very few of those houses whose inhabitants live orderly and comfortably, and have by nature healthy constitutions, (you must take all these together) are infected; and I can say, (God be praised for it) that as yet not one of my acquaintance, except an under post-master, who lived closely and nastily, and had all sorts of people coming to his house with letters, is dead: so that, generally, they are bodies corrupted, and persons wanting necessaries and comfortable relief, that suffer most by this contagion.

That observation, you mention of Mr. *Boyle's*, is this, that one of those two physicians, Dr. *Clerk*, and Dr. *Lower*, had assured him, that he had several times found, in the lungs of sheep, a considerable quantity of grass, in the very branches of the *Aspera Arteria*; and the other had related to him, that a few weeks since, he, and a couple of physicians more, were invited to look upon an ox, that had, for two or three days, almost continually held his neck straight up, and was dead of a disease, the owner could not conjecture at; whereupon the parts belonging to the neck and throat being opened, they found, to their wonder, the *Aspera Arteria*, in its very trunk, all stuffed with grass, as if it had been thrust there by main force; which gives a just cause of marvelling and enquiring, both how such a quantity of grass should get in there, and how being there, such an animal could live with it so long.

Sept. 26.

LETTER FROM HOOKE TO BOYLE.

Durdens, Sept. 26, 1665.

Most honoured Sir,

I was a little troubled at the miscarriage of my last letter, and

[1]Printed in Derham, *Phil. Experiments*, 1726, p. 28.

so much the more, because I could not till now find an opportunity of repeating my request I therein made. I did therein, as I remember, send an account of some trials I had then newly made in a well not far from us, which, upon measuring, I found to be no less than three hundred and fifteen foot in its perpendicular depth, though that was short also of the depth, that I was assured it was of, before it had been filled up by timber, stones, and other rubbish; for the owner of it affirmed it to be no less than seventy fathoms deep by measure, or four hundred and twenty foot, so that it seems no less than a hundred foot is filled with rubbish, at least it is stopped by some cross timber, which I rather suspect, because that I found the weights to be stayed by them, if I suffered them to descend below that depth. One of the experiments I tried in it was that of gravity, which upon accurate trial I found to succeed altogether as the former, whereof I gave you an account before. I tried also an experiment in it with four large candles, lighted and placed at a convenient distance, one from another, in sockets fastened on a board for that purpose. The issue was, that they burnt very freely, and blazed, till they had descended about two hundred and forty foot from the top, where they suddenly began to grow dim, and quickly after went out all together, as if suddenly quenched or extinguished by their sinking into a damp; which if so, the damp must be no less than threescore foot deep. I was not then able to repeat the experiment, by reason of the loss of those candles by an unlucky accident before I had got up the line.; nor have not since had time, but I propose, God willing, shortly the further prosecution of it, together with a long series of experiments, which I have thought on, it being such an opportunity, as is scarce to be met with in any other place I know. I have in my catalogue already thought on divers experiments of heat and cold, of gravity and levity, of condensation and rarefaction of pressure, of pendulous motions and motions of descent; of sound, of respiration, of fire, and burning, of the rising of smoke, of the nature and constitution of the damp, both as to heat and cold, driness and moisture, density and rarity, and the like. And I doubt not but some few trials will suggest multitude of others, which I have not yet thought of; especially if we can by any

means make it safe for a man to be let down to the bottom. I should very gladly receive from you, if it be not too great a trouble, a catalogue of such experiments, as you shall think fit to be tried to it, which was indeed the chief business of my last scribble. I am going shortly for a little while into the *Isle of Wight*, and so perhaps may not till my return be able to make those trials; but I suppose the winter will not afford less instructive experiments than the other. And therefore what you shall please to suggest now will not come too late for winter experiments, especially if I can give order for making ready an apparatus for them before I take my journey, which I shall be able to do, if by the return of this bearer you please to send them to,

Most honoured Sir,
your most humble, and
most faithful servant,
ROB. HOOKE.

1665/6

Feb. 3.

LETTER FROM HOOKE TO BOYLE.

Gresham College, February 3, 1666.

Most honoured Sir,

I did by my last letter, which I sent to you from *Durdens*, acquaint you with my last trials, which I made in the deep wells, which were indeed so considerable, that I have many times since wished, that I could have another opportunity of examining them further. Whether that and another I sent not long before came to your hands, I now begin to doubt, being assured, that many other letters, which I sent from *Epsom* to be delivered at the post house, in that time of confusion, miscarried, especially since Mr. OLDENBURG tells me, that you have intimated to him, that it is much longer since you have received any from me. I am somewhat troubled, indeed, that my last did miscarry, if it has so, because therein I had set down, whilst they were fresh in my memory, most of the particulars, which I thought most observable in those trials. The sum of which, if I misremember not, was this; that the air at the bottom of the well was exceeding hot, when the air above was so very cold, that every thing froze

immediately almost; so that, notwithstanding the great increase of pressure at that depth, yet the air in the instrument we let down for that purpose was abundantly much more rarified at the bottom, than it was before we had let it down, and after we had pulled it up. Another thing, which was not less observable, was, that all the glass vessels we let down into the well were, when we pulled them up, all covered over very thick with great drops of dew or water, so that from one of the bottles, I believe, several spoonfuls might have been collected; and notwithstanding this, the hygroscope I let down at the same time manifested, that the air at the bottom was exceeding much drier than it was at the top; the candles, which we divers times tried, went out much about the same depth always; and sometimes, by suddenly pulling them up about half a dozen fathom, they would rekindle, and burn afresh. We found but little difference between the time, that wooden and leaden bullets descended this space; nor could I sensibly distinguish, that there was any difference between the resounding eccho from the bottom, and the like eccho from an horizontal wall equally distant upon the ground, though the return were very much stronger, but more confused by the greatness of the noise. The weather was so very cold, when we made these experiments, that made us hasten then so much the more; and I have not since had an opportunity to repeat them, though, God willing, I intend to make many other of the like kind, either there or elsewhere, some time this summer; and I have great hopes of having an opportunity of examining both greater depths and much greater heights, in some of our English mines, and some of the mountains in *Wales*, which, with some other good company, I design to visit this next summer. Mr. TILLOTSON has a very young child, which, from the swelling of the joints, some imagine to have the rickets; and, upon my naming of your ens veneris, he has much desired me to procure him some of it. I would desire therefore in your next, that you would be pleased to direct me, where I may meet with some of it, that is good and well made, that I may procure for him. I am now making a collection of natural rarities, and hope, within a short time, to get as good as any have been yet made in the world, through the bounty of some of the noble-minded persons

of the Royal Society. I hope we shall have again a meeting, within this week or fortnight at farthest, there being now a sufficient number of our members in town; and then I hope we shall prosecute experiments and observations much more vigorously; in order to which also I design, God willing, very speedily to make me an operatory, which I design to furnish with instruments and engines of all kinds, for making examinations of the nature of bodies, optical, chemical, mechanical, *&c.* and therein to proceed by such a method, as may, I hope, save me much labour, charge, and study; and in this design there will be some two or three others, that will join with me, who, I hope, are of the same mind with me. But I much forgot my self, to trouble you, Sir, with these my impertinencies, before they are completed; though, when they are so, I must beg, that you will send a word or two of directions (concerning some chemical operations and methods) to,

Most honoured Sir,

your most humble servant,

R. HOOKE.

Chariots.

Mar. 14. The President inquiring into the employments, in which the members of the society had been engaged during their long recess, several of those, who were present, gave some account thereof: viz.

Dr. WILKINS and Mr. HOOKE of the business of the chariots, viz. that after great variety of trials they conceived, that they had brought it to a good issue, the defects found, since the chariot came to London, being thought easy to remedy. It was one horse to draw two persons with great ease to the riders, both him who sits in the chariot, and him who sits over the horse upon a springy saddle; that in plain ground 50-pound weight, descending from a pully, would draw this chariot with two persons. Whence Mr. HOOKE inferred, that it was more easy for a horse to travel with such a draught, than to carry a single person: That Dr. WILKINS had travelled in it, and believed, that it would make a very convenient post-chariot.

It was ordered, that Dr. WREN and Mr. HOOKE should join in mending what might be amiss in this chariot, and endeavour to bring it to perfection.

Weights in a Well.

Mr. HOOKE gave an account of what experiments he had made

by weighing bodies in a very deep well,[1] and above ground; and that he had found no difference in their weight in those different places. He was ordered to bring in these experiments in writing.

New Quadrant.

Mar. 21. Mr. HOOKE brought in a small new quadrant, which was to serve for accurately dividing degrees into minutes and seconds, and to perform the effect of a great one. It had an arm moving on it by the means of a screw, that lay on the circumference. But the complete description of it was referred to the inventor.

Gravity.

He presented a paper, which was read, containing some experiments of gravity made in a deep well near Banstead Downs in Surrey; to which was annexed the scheme of an instrument for finding the difference of the weight, if any, between a body placed on the surface of the earth, or at a considerable distance from it, either upwards or downwards. It was ordered, that this paper should be registered; as follows:

Gravity, though it seems to be one of the most universal active principles in the world, and consequently ought to be the most considerable, yet has it had the ill fate, to have been always, till of late, esteemed otherwise, even to slighting and neglect. But the inquisitiveness of this latter age hath begun to find sufficient arguments to entertain other thoughts of it. GILBERT began to imagine it a magnetical attractive power, inherent in the parts of the terrestrial globe: the noble VERULAM also, in part, embraced this opinion; and KEPLER (not without good reason) makes it a property inherent in all celestial bodies, sun, stars, planets. This supposition we may afterwards more particularly examine: But first it will be requisite to consider, whether this gravitating or attracting power be inherent in the parts of the earth; and, if so, whether it be magnetical, electrical, or of some other nature distant from either.

First then, if it be magnetical, any body attracted by it ought to gravitate more, when nearer to its surface, than when farther off.

To examine which property, several trials have been made, both on the higher parts of Westminster Abbey, and also at the top of St. Paul's tower: But though in the making of them, I endeavoured to be as accurate as the way was capable of, I took to try it, which was by counterpoising a heavy solid body, and as much brass wire, as would serve to let down that body

[1] See his letters to Mr. BOYLE of August 15, and September 26, 1665, from BOYLE's Works, vol. v, p. 544, reprinted below.

from the top to the bottom of the tower, and then poising these equilibrated bodies first, whilst the solid body and wire were in the scale at the top; and afterwards by poising them likewise, when the body was let down almost to the bottom by the wire, (whose upper end was fastened to the scale at the top); yet such were the inconveniences, this way was subject to, from the vibrations of so long a line, and from the motion of the interposed air, that nothing of certainty could be collected from these trials; save only, that if there were any difference in the gravitation of the body, it was but very small and inconsiderable, since I found in the trials made from the top of the abbey, that a few grains put into this or that scale would manifestly turn the beam this or that way, notwithstanding the former inconveniences. But to distinguish, whether there be any the least variety, there must be attempted some other way: of which by and by.

Next, if all the parts of the terrestrial globe be magnetical, then a body at a considerable depth, below the surface of the earth, should lose somewhat of its gravitation, or endeavour downwards, by the attraction of the parts of the earth placed above it.

This opinion some experiments, made by some worthy persons of this honourable society, seem to countenance. But considering the vast proportion of the decrease of gravity at so small a depth, it seemed not improbable, but that the moisture of the air, or some other unheeded accident, might intervene in the experiments, which might much contribute thereunto: For the trial of which I had a great desire, and happily meeting with some considerably deep wells, near Banstead Downs, in Surrey, I endeavoured to make them with as much exactness and circumspection as I was able. My first trials were in a well about 15 fathoms deep, or 90 feet; the packthread I made use of was about 80 feet long; the bodies I weighed, or let down by it, were brass, wood, and flints; each of which, at several times, I counterpoised exactly, and hung the scales, which were very good ones, over the midst of the well, so as that the packthread might hang down to the bottom without touching the sides. The effects were these, that each of those bodies seemed to keep exactly the same gravity at the bottom of the well, that they had at the top. For, trying it when the air was very calm and still, I found, that the weight of a grain would easily turn the scales either ways, according as it was put into the one or the other scale; which exactness of equipollency in the scale I found both before I let down the body by the packthread, when they were so let down, and after they were again drawn up; so that it seemed manifest, that about a pound weight, either of wood, flint, or brass, by being placed fourscore feet either nearer or farther from the

centre of the earth, did not vary its weight more than a grain; that is, not more than a 768oth part of its weight, by having eighty feet of earth situate above it; whereas the other experiments make it lose near a 16th part, at a depth not much greater.

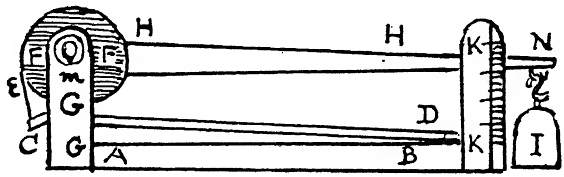
This experiment I afterwards tried with the like circumspection in a well of near sixty fathoms deep, where the weight, though suspended at the end of a string of about 330 feet long, seemed to continue of the same weight, that it had above, both before it was let down, and after it was pulled up: for the beam of the balance, though very tender, did in all those trials, (that is, before the weight was let down, when it was let down and suspended, and after it was again drawn up) keep, as to sense, exactly its horizontal parallelism or equilibration: So that this opinion, how probable soever it might seem to GILBERT, VERULAM, and divers other learned men, is not at all favoured by the experiments made in these wells; whether from the peculiar nature of the earth about these wells, which was a pretty solid chalk; or whether from some other cause, I determine not, till further experiments evince it. But in truth, upon considering the nature of the theory aright, we may find, that (supposing the theory true, that all the consistent parts of the earth had a magnetical or attractive power) the decrease of gravity would be almost an hundred times less than a grain to a pound, at as great a depth as 50 fathom. For if we consider the proportion between the parts of the earth placed upon the one side of the stone below it, with the parts above it, we may find the disproportion greater. If therefore there be any such inequality of gravity, we must have some ways of trial much more accurate, than this of scales: Of which I shall propound two sorts, which, if there be any difference, seem capable of distinguishing and finding it out.

The first is by the motion of a swing-clock: for if the attraction of the earth towards its centre be less, the farther the body is placed above or below its surface, then the motion of such a watch must be slower there than when placed on the surface: And though perhaps it be so small as not to be sensible at one, or ten, or perhaps an hundred vibrations, yet in many thousands of them, it will not be difficult to find it. But a clock for this experiment ought to be sealed up exactly in a glass, so that no air may have any intercourse with it; which is sufficiently easy; otherwise the changes of it may perhaps be rather ascribable to the air, which is most evidently of a differing constitution. And by this means (which I look upon as the most exact) I could wish, that trial were made at the top and bottom of some very high hill, that so, by the differing velocity of the clock, at the

top of the hill, from that at the bottom, we might be able to judge, whether there be any such variation of gravity; and, if such there be, whether it be analogous to that of a loadstone.

The other instrument for this purpose may be some such as this, described in the adjoining figure, which ought also to be well fortified against the mutations of the ambient air: otherwise in so nice an experiment nothing can be done.

Now because the design of both these instruments is, to find out a difference of gravity, if there be any, to the end, that by comparing them with the attraction of the loadstone, we may the better judge of this supposition; it will therefore be requisite, to make several experiments on a good magnet, for the finding out of the decrease of the force of its attractive power upon



a body, according as it is placed, at greater and greater distances. For which, I have contrived and designed to make an appropriate instrument. Which experiments, as they are wholly new, being not attempted hitherto (that I know) by any; and as they may afford many helps toward the finding out the true nature of the magnet, and the laws and reasons of divers other motions; so if this analogy between the decrease of the attraction of the one, and of the gravity of the other, be found real, we may perhaps by the help of the loadstone, as it were, epitomize all the experiments of gravity, and determine, to what distance the gravitating power of the earth acts; and explicate perhaps divers other phenomena of nature by ways not yet thought of.

The description of the instrument is as follows,

AB a frame, to which is fastened CD a spring, from the end of which C a thread CE is fastened to a small wheel FF, which moves on a very sharp edge, in the hole m. To the other side of this wheel is fastened a small long beam HH, reaching beyond the frame AB, namely to N, to which end a weight of a convenient bigness I being hung, and the instrument carefully conveyed from place to place, the end of the beam will show upon the divided pillar KK the differing weight of that body in several places.

Repository.

Dr. WILKINS moved, that a committee might be appointed to

take care of the well-ordering, preserving, and increasing the stock of the Society's repository. Upon which it was ordered, that himself, Mr. COLWALL, Mr. EVELYN, Dr. GODDARD, Dr. CHARLTON, Mr. HILL, Capt. COCK, Mr. HARRINGTON, Mr. GRAUNT, and Mr. HOOKE, or any three or more of them, should constitute that committee, and begin their meetings on the Monday following in the afternoon, in Mr. HOOKE's lodgings, continuing the same from time to time on that day, and in that place.

Salterns.

Mr. HOOKE related, that in the salt-urns in Hampshire he had observed, that a good quantity of sand, near a gallon, was separated from the clear sea-water in the boiling it up to salt; which sand was collected out of the corners of the iron vessel, wherein the said water was boiled.

'*On the manufacture of Salt in a Hampshire Saltern.*' With a figure. R. S. MS. 40, 42.

Chariots.

Dr. WREN and Mr. HOOKE being asked, what they had done in the business of chariots, since the perfecting thereof was committed to them, Dr. WREN answered, that he had given Mr. HOOKE the descriptions of those, which they had in France.

Mar. 21.

LETTER FROM HOOKE TO BOYLE.

March 21, 1665–6.

Honoured Sir,

This account having had the honour to be very well approved in the Royal Society, though the experiments contained in it are no other than what I have formerly acquainted you with, yet there being somewhat of new hypothesis, and giving some account of the apparatus which is now preparing for the trial of those experiments, and somewhat likewise of the main drift of them, I have added them to this scribble. Mr. TILLOTSON returns his humble service for the ens Veneris you were pleased to promise him, but I have since procured him some very good here in town, which has served the turn so, that I shall give you no further trouble concerning it. I have given Mr. SHORTGRAVE directions for making of a wheel baroscope for you by a new way, which is much more facil than the former, both in making, filling, and rectifying. He shews me likewise some brass pipes, which if they be for injection, or transfusion of blood, they would be somewhat

better to have small protuberances left at the end, that they may not slip out of the vessel, when they are tied on to it; but knowing not the designs of them, I could not direct him. I very much rejoice to hear of your return to these parts, and am glad you have made choice of this end of the town: the place I was lately to see, and believe it to be a very good air; it is pleasant, private, and there is a very good neighbourhood, and it is not full three miles from hence all over pleasant fields. I do not hear of the death of any of your workmen save Mr. THOMPSON, and Mr. SHAW the founder; and here are others of the same trade good workmen. I thought to have conveyed this by Dr. WREN, who is this day gone for *Oxford*, but I was hindered by company this morning. He has something worth your perusal; amongst the rest a relation of *China*, new and very good of its kind, though it contain not much of philosophical information till towards the latter end, much of which seems to be transcribed from others. Two or three leaves I have turned down in it on such things as I met with remarkable. But I have already given you too much trouble, and therefore beg your pardon. I am,

Honoured Sir,

your most humble, and

most faithful servant,

R. HOOKE.

Our collections of rarities at *Gresham* college is now very well worth your persual, and I hope to increase it every day. We had yesterday a very full meeting here of the Society, and I hope a greater the next week. I am very glad to hear, that you have a sixty foot telescope; certainly it may help us to many good discoveries, if it be well made use of. I did the last week see an elliptical glass, which in truth did something extraordinary, and more than I had seen before; and I expect shortly to see much better.

1666

Mars.

Mar. 28. Mr. HOOKE presented a paper containing some observations made by himself of the planet Mars, in the face whereof he affirmed to have discovered, during the last months

of February and March, both that there were several spots, and that they changed their place, and did not return to the same position till the next ensuing night near about the same time; collecting thence, that Mars, as well as Jupiter, the earth, &c. moves about his own axis in about 24 hours. To which he added his observations concerning the different dispositions of the air, as to its greater or less fitness to see through it, affirming, that frequently a very bright sky was altogether unfit for observation; but that when it had fewer reflecting vapours dispersed through it, it was then most transparent, and consequently most proper for it.

Mr. HOOKE was desired to continue his observations for further confirmation; and it was ordered, that his paper should be registered.[1]

Magnetic Attraction.

He produced a pair of scales in a box, to make experiments with upon a good loadstone for the finding out of the decrease of its attractive force upon a body, according as it is placed at greater and greater distances, in order to find out, whether gravitation be somewhat magnetical; which he said might be done by comparing the distances of the bodies made use of in the experiments from the superficies of the earth and loadstone with the diameters; it being probable, that if they hold the same proportion, they have the same cause.

It was ordered, that he should make in it several experiments by himself, and then make them before the society.

April 2.

(7) *Some new Observations about the Planet Mars.*[1]

April 4. Mr. HOOKE presented a table of the degrees of the loadstone's attraction of a little square oblong piece of iron at several distances from the pole of the magnet, as he had found it in making trials privately himself, viz.

	grains
at 6 inches	0
at 4 inches	$0\frac{1}{8}$
at 2 inches	$2\frac{13}{16}$
at 1 inch	$17\frac{6}{8}$
at $\frac{1}{2}$ of an inch	$57\frac{6}{8}$
at $\frac{1}{4}$ of an inch	$104\frac{5}{16}$
at $\frac{1}{8}$ of an inch	$197\frac{4}{8}$

[1] Register, vol. iii, p. 98. It is printed in the *Philosophical Transactions*, No. 2, p. 198, and No. 14, p. 239.

Which trials being repeated before the society held good, except, that instead of the $2\frac{13}{16}$ grains at 2 inches distance, the weight was $3\frac{3}{4}$ grains; and instead of $17\frac{6}{8}$ grains at 1 inch distance, the weight was $18\frac{7}{8}$ grains, to equal the attraction.

A thin plate of steel being interposed at about an inch distance made the weight less by 14 grains.

Magnetic Watch.

Apr. 18. Mr. HOOKE produced a new kind of watch, the motion of which was regulated by a loadstone, the balance of it being a rod of steel; concerning which the President declared, that this way might do best of all, in case the magnet kept always the same temper.

Springy Saddle.

The springy saddle contrived by Mr. HOOKE was tried, and an exception being made against the narrowness of the seat, and the way of hanging on the stirrups, it was ordered, that against the next meeting it should be made with a full seat, and with the stirrups hanging from the seat itself.

Streeter's Painting.

Mr. POVEY mentioned a new way of painting used by one Mr. STREETER, by means whereof he affirmed a picture appeared very well without glaring. He offering to go with Mr. HOOKE to the artist, to see the operation itself, his offer was accepted. and Mr. HOOKE ordered to attend him accordingly.

Terrella.

Apr. 25. Mr. HOOKE showed by a terrella, that the lines of a loadstone's direction are all ovals, of which the centre of the magnetic globe is the place of contact, and the axis of them perpendicular to the axis of the terrella. This was performed by suspending and letting freely move a needle upon a small triangular piece of wood, and marking the points of it with respect to the magnet; all which fell into an oval.

He offered his thoughts of an hypothesis, for explicating all the phenomena of a loadstone; which he was desired to give in to the next meeting.

He affirmed, that he had put all sorts of bodies between a magnet and iron, and that none altered the attraction except iron.

Lines of Magnetic Force.

May. 2. Some experiments were made with two loadstones, one a terrella, the other of an irregular figure. Some steel-dust

being scattered about them, there appeared upon the different position of the latter in respect of the former different and odd postures in the steel-dust. Mr. HOOKE was ordered to describe these postures in schemes, and to bring them in to the society.

May 7.

(8) *A Method by which a glass of a small Plano-convex Sphere may be made to refract the Rayes of light to a Focus of a far greater distance than is usual.*

Reprinted on p. 196. *Phil. Trans.*, xii, pp. 202–3, May 7, 1666.

May 9. Two magnetical experiments were made by Mr. HOOKE. One was, that the terrella being so placed, as to have its poles perpendicular to the horizon, the steel-dust held over it in a sieve, and put into motion, was, instead of being attracted, chased away from both the poles in two several trials; and the same terrella being placed horizontally, and the steel-dust held again over it, it was likewise driven from both the poles at once. The same was tried with a magnet of an irregular figure with the like success. The other experiment was, that the terrella being put in the midst of a board in a hole, and the steel-dust ranged in oval figures about it, a small loadstone being placed on the same board, the dust, when put into motion, was determined by it into analogous oval figures; which seemed to show how the loadstone conforms itself to the earth.

Chariots.

The business of chariots being again spoken of, the President related, that as Mr. HOOKE's chariot was now contrived, it was better than before, and free from jolting.

Variation of Magnetic Needle.

May 16. A paper of Mr. PHILIPS was brought in by Mr. HOOKE concerning the variations of the magnetic needle, as they had been observed in two East India voyages.

Celestial Motions Represented by Pendulums.

It being mentioned by Mr. HOOKE, that the motion of the celestial bodies might be represented by pendulums, it was ordered, that this should be showed at the next meeting.

Bearing of Madrid from London.

May 23. The President produced a letter and a note sent him by the Earl of SANDWICH out of Spain, wherein his lordship

offered himself to make observations for finding the bearing of Madrid from London, and desired a correspondent to observe the same times in England. Mr. HOOKE in London and Dr. WALLIS at Oxford were fixed upon for that correspondency; and it was ordered, that the latter should be written to by Mr. OLDENBURG, to acquaint him with this appointment.

Lunar Distances.

Mr. HOOKE proposed, that the distance of the moon's centre from two or more fixed stars, when she is full south, as well as the other places mentioned by the Earl of SANDWICH, might be observed.

Jupiter's Satellites.

He was ordered to take the paper of Mr. ROOKE, delivered by Sir ROBERT MORAY to Mr. OLDENBURG, containing some observations of the satellites of Jupiter, and to deduce thence the periods of their revolutions.

Motion in a Curve. A Statement of Planetary Movements as a Mechanical Problem.

A paper of Mr. HOOKE concerning the inflexion of a direct motion into a curve by a supervening attractive principle was read, and ordered to be registered,[1] and was as follows:

I have often wondered, why the planets should move about the sun according to COPERNICUS'S supposition, being not included in any solid orbs (which the ancients possibly for this reason might embrace) nor tied to it, as their centre, by any visible strings; and neither depart from it beyond such a degree, nor yet move in a straight line, as all bodies, that have but one single impulse, ought to do: For a solid body, moved in a fluid, towards any part, (unless it be protruded aside by some near impulse, or be impeded in that motion by some other obviating body; or that the medium, through which it is moved, be supposed not equally penetrable every way) must preserve in its motion in a right line, and neither deflect this way nor that way from it. But all the celestial bodies, being regular solid bodies, and moved in a fluid, and yet moved in circular or elliptical lines, and not straight, must have some other cause, besides the first impressed impulse, that must bend their motion into that curve. And for the performance of this effect I cannot imagine any other likely cause besides these two: The first may be from an unequal density of the medium, through which the planetary body is to be moved; that is, if we

[1] Register, vol. iii, p. 114. See Mr. WALLER'S life of Dr. HOOKE, p. 12. The original paper, illustrated with two diagrams, is in R. S. MS. No. 41.

suppose that part of the medium, which is farthest from the centre, or sun, to be more dense outward, than that which is more near, it will follow, that the direct motion will be always deflected inwards, by the easier yielding of the inward, and the greater resistance of the outward part of that medium. This hath some probabilities attending it; as, that if the ether be somewhat of the nature of the air, 'tis rational, that that part, which is nearer the sun, the fountain of heat, should be most rarefied; and consequently that those, which are most remote, should be most dense: But there are other improbabilities, that attend this supposition, which being nothing to my present purpose I shall omit.

But the second cause of inflecting a direct motion into a curve may be from an attractive property of the body placed in the centre; whereby it continually endeavours to attract or draw it to itself. For if such a principle be supposed, all the phenomena of the planets seem possible to be explained by the common principle of mechanic motions; and possibly the prosecuting this speculation may give us a true hypothesis of their motion, and from some few observations, their motions may be so far brought to a certainty, that we may be able to calculate them to the greatest exactness and certainty, that can be desired.

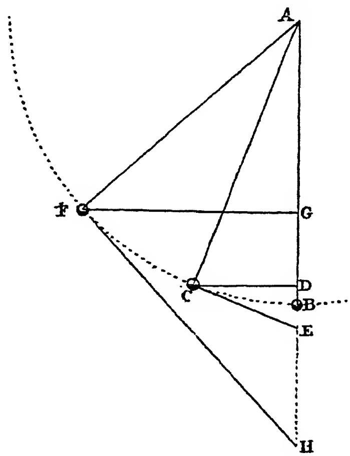
This inflexion of a direct motion into a curve by a supervening attractive principle I shall endeavour to explicate from some experiments with a pendulous body: not that I suppose the attraction of the sun to be exactly according to the same degrees, as they are in a pendulum: for in a circular pendulum the degrees of conatus at several distances from the perpendicular are in the same proportion with the sines of their arches of distance; as is evident by the figure.

Let AB represent a pendulum hanging perpendicular, suspended at A: if it be moved out of it, as to C or F, the conatus of the body to descend in the point C to the conatus in F shall be always as CD to FG. For it is a common principle of mechanics, that the conatus of a body descending in an inclining plane to that of one descending perpendicular, is in reciprocal proportion to the length of those planes included between two horizontal parallel lines: As if there be a body at C, and another at D, the one descending by CE, the other by DE, the conatus in CE to that in DE shall be as DE to CE; that is as CA to CD. The same may be also proved of a ball at F and G, that the conatus of the body to descend in GH to that descending in FH, shall be as FH to GH; that is as AF to FG: Therefore the conatus in C to that in F, shall be as CD to FG; and consequently the conatus of returning to the centre in a pendulum is greater

and greater, according as it is farther and farther removed from the centre, which seems to be otherwise in the attraction of the sun; as I may afterwards further explain.

But however it be, the compounding this motion with a direct or straight motion just crossing it, may serve to explicate this hypothesis, though all the appearances of it are not exactly the same. As for instance, &c.

By this hypothesis, the phenomena of the comets as well as of the planets may be solved; and the motions of the secondary as well as of the primary planets: The motions also of the progres



sion of the auges are very evident. But as for the motion of libration or latitude, that cannot so well be made out by this way of pendulum; but by the motion of a wheel on a point is most easy.

This discourse was an introduction to an experiment to show, that circular motion is compounded of an endeavour by a direct motion by the tangent, and of another endeavour tending to the centre. For which purpose there was a pendulum fastened to the roof of the room with a large wooden ball of lignum vitae on the end of it. And it was found, that if the impetus of the endeavour by the tangent at the first setting out was stronger than the endeavour to the centre, there was then generated an elliptical motion, whose longest diameter was parallel to the direct endeavour of the body in the first point of impulse. But if that impetus was weaker than the endeavour to the centre, there was generated such an elliptical motion, whose shorter diameter was parallel to the direct endeavour of the body in the first point of

impulse. And if they were both equal, there was made a perfect circular motion.

There was also made another experiment by fastening another small pendulous body by a shorter string on the lower part of the wire, by which the greater weight was suspended, that it might freely make a circular or elliptical motion round the bigger, whilst the bigger moved circularly or elliptically about another centre. The intention whereof was to explain the manner of the moon's motion about the earth, it appearing evidently thereby, that neither the bigger ball, which represented the earth, nor the less, which represented the moon, were moved in so perfect a circle or ellipse, as otherwise they would have moved in, if either of them had been suspended and moved singly; but that a certain point, which seemed to be the centre of gravity of these two bodies, howsoever posited (considered as one) seemed to be regularly moved in such a circle or ellipse, the two balls having other peculiar motions in small epicycles about the said point.

Comets.

Mr. Hooke gave in his remarks upon Monsieur Petit's dissertation of the nature of comets, which had been presented to the society some weeks before by the author, and referred to Mr. Hooke's perusal; the substance of whose sentiments upon it were, that he found, that Monsieur Petit's observations of the two last comets agreed in the general with those made by himself, and with the best, which he had met with of others: And that the hypotheses mentioned in that discourse were very ingenious, and some of them not improbable. But whether the comets were moved in equal spaces of a curve line in equal spaces of time (which Monsieur Petit seemed inclined to believe) deserved to be further examined by such observations, as had been made accurate enough to determine the distance or parallax of them in several places of their appearance.

New Chariots.

Col. Blount and Mr. Hooke were desired to appear on the Saturday following in the afternoon in St. George's Fields, with their new chariots, to compare them together; and it was requested, that as many of the society, as conveniently could, would meet them there.

Pendulum.

It was ordered, that Mr. Hooke should give an account of his experiments with the pendulum mentioned above in writing at large, together with the discourse, which he made upon them.

June 4.

(9) *A new Contrivance of a Wheel-Barometer, much more easy to be prepared than that which is described in the* Micrography; *imparted by the author of that book.* With a figure.

Phil. Trans., xiii, pp. 218–19, June 4, 1666.

Fossil Echinus.

June 13. Mr. HOOKE brought in a petrified fish called *Echinus Spaticus*, by which he conceived his notion of figured stones to be confirmed.

Circular Pendulum for Watch.

Mr. HOOKE exhibited a new contrivance of a circular pendulum applicable to a watch, and moving without any noise, and in continued and even motion without any jerks.

He was desired to show the use of it in a watch, which he said the President had already given order for.

Jupiter's Satellites.

June 20. Mr. HOOKE mentioned, that he had observed a new spot in Jupiter different from those, which he had formerly observed in that planet, and in another belt. He added, that he had seen the satellites of Jupiter with Mr. BOYLE's sixty-foot glass as bright as he saw Jupiter himself with the naked eye.

Parallax.

He undertook to make observations of the parallax of the earth's orb to seconds; as also to make observations with long telescopes without the use of a tube.

Hygroscope.

June 27. Mr. HOOKE produced a new substance fit for a hygroscope, much stronger and better than the beard of a wild oat. It was the cod of a vetch, which was tried before the society, and answered expectation.

Jupiter.

He brought in likewise his observations made upon Jupiter, June 26, with a sixty-foot glass, which were ordered to be registered.

Eclipse of Sun.

The observations of the solar eclipse on the 22nd of June, made by Mr. WILLUGHBY, Dr. POPE, Mr. HOOKE, and Mr. PHILIPS were also communicated, and ordered to be registered.

Pendulums and the Springy Saddle.

The experiments appointed for the next meeting were:

1. The prosecution of a circular pendulum to be applied to a clock.

2. The two balls on a pendulum, to show the motion of the earth and moon, with the contrivance of a sand-box to have the sand run out, for representing the line of that motion.

3. The springy saddle upon two wheels.

July 2.

(10) *The Particulars of those observations of the planet Mars formerly intimated to have been made at London in the months of February and March 1665–6.*

Phil. Trans., xiv, pp. 239–42, July 2, 1666.

(11) *Some observations lately made at London concerning the planet Jupiter.* [June 26, 1666].

Phil. Trans., xiv, pp. 245–7.

(12) *A late observation about Saturn made by the same.* [June 29, 1666].

(13) *A Method for making a History of the Weather.*

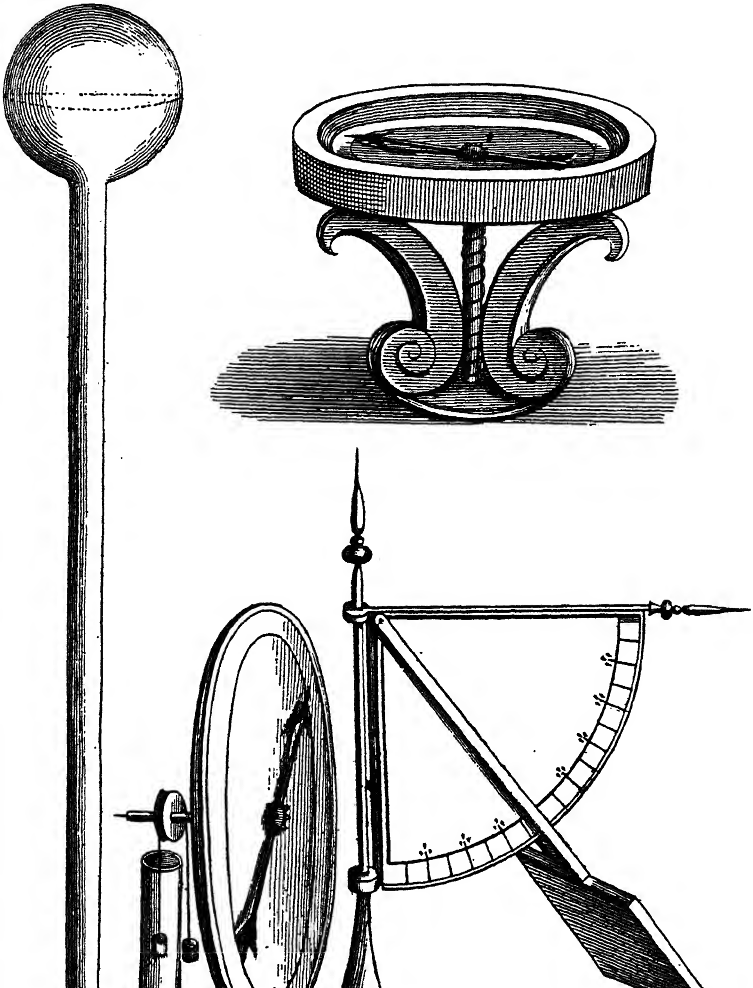
Sprat, *History of the Royal Society*, 1667, p. 173.

Although written long before, this illustrated discourse on Meteorological instruments and the weather may be appropriately printed here.

For the better making a History of the Weather, I conceive it requisite to observe,

1. The Strength and Quarter of the Winds, and to register the Changes as often as they happen: both which may be very conveniently shewn, by a small addition to an ordinary Weather-clock.

2. The Degrees of Heat and Cold in the Air; which will be best observed by a sealed *Thermometer*, graduated according to the Degrees of *Expansion*, which bear a known proportion to the whole bulk of Liquor, the beginning of which gradation, should be that dimension which the Liquor hath, when encompassed with Water, just beginning to freeze, and the degrees of *Expansion*, either greater or less, should be set or marked above it or below it.



1. A Hygroscope made with a single beard of a wild Oat.

2. An Instrument with Quicksilver contrived with an Index to sensibly exhibit minute variations of Pressure in the Air.

3. Instrument for measuring the Strength of the Wind.

(Sprat, *History of the Royal Society*, 1667, p. 173.)

3. The Degrees of Dryness and Moisture in the Air; which may be most conveniently observed by a *Hygroscope*, made with the single beard of a wild Oat perfectly ripe, set upright and headed with an *Index*, after the way described by *Emanuel Magnan*; the conversions and degrees of which, may be measured by divisions made on the rim of a Circle, in the *Center* of which, the *Index* is turned round: The beginning or Standard of which Degree of *Rotation*, should be that, to which the *Index* points, when the beard, being throughly wet, or covered, with Water, is quite unwreathed, and becomes straight. But because of the smallness of this part of the Oat, the cod of a wild *Vetch* may be used instead of it, which will be a much larger *Index*, and will be altogether as sensible of the changes of the Air.

4. The degrees of Pressure in the Air: which may be several wayes observed, but best of all with an Instrument with Quick-silver, contrived so, as either by means of water or an *Index*, it may sensibly exhibit the minute variations of that Action.

5. The constitution and face of the Sky or Heavens; and this is best done by the eye; here should be observed, whether the Sky be clear or clouded; and if clouded, after what manner; whether with high Exhalations or great white Clouds, or dark thick ones. Whether those Clouds afford Fogs or Mists, or Sleet, or Rain, or Snow, *&c*. Whether the under side of those Clouds be flat or waved and irregular, as I have often seen before thunder. Which way they drive, whether all one way, or some one way, some another; and whether any of these be the same with the Wind that blows below; the Colour and face of the Sky at the rising and setting of the Sun and Moon; what Haloes or Rings may happen to encompass those Luminaries, their bigness form and number.

6. What Effects are produc'd upon other bodies: As what Aches and Distempers in the bodies of men: what Diseases are most rife, as Colds, Fevours, Agues, *&c*. What putrefactions or other changes are produc'd in other Bodies; As the sweating of Marble, the burning blew of a Candle, the blasting of Trees and Corn; the unusual sprouting, growth, or decay of any Plants or Vegetables: the putrefaction of bodies not usual; the plenty or scarcity of Insects; of several Fruits, Grains, Flowers, Roots, Cattel, Fishes, Birds, any thing notable of that kind. What conveniences or inconveniences may happen in the year, in any kind, as by floods, droughts, violent showers, *&c*. What nights produce dews and hoar-frosts, and what not?

7. What Thunders and Lightnings happen, and what Effects they produce; as souring Beer or Ale, turning Milk, killing Silk-worms, *&c*?

8. Any thing extraordinary in the Tides; as double Tides later

or earlier, greater or less Tides than ordinary, Rising or drying of Springs; Comets or unusual Apparitions, new Stars, *Ignes fatui* or shining Exhalations, or the like.

These should all or most of them be diligently observed and registred by some one, that is alwayes conversant in or neer the same place.

Now that these and some other, hereafter to be mentioned, may be registred so as to be most convenient for the making of comparisons, requisite for the raising *Axioms*, whereby the Cause or Laws of Weather may be found out; It will be desirable to order them so, that the Scheme of a whole Moneth, may at one view be presented to the Eye: And this may conveniently be done on the pages of a Book in folio, allowing fifteen dayes for one side, and fifteen for the other. Let each of those pages be divided into nine Columes, and distinguished by perpendicular lines; let each of the first six Columes be half an inch wide, and the three last equally share the remaining of the side.

Let each Colume have the title of what it is to contain, in the first at least, written at the top of it: As, let the first Colume towards the left hand, contain the dayes of the Moneth, or place of the Sun, and the remarkable hours of each day. The second, the Place, Latitude, Distance, Ages and Phases of the Moon. The third the Quarters and strength of Winds. The fourth the Heat and Cold of the season. The fifth the Dryness and Moisture of it. The sixth the Degrees of pressure. The seventh the faces and appearances of the Sky. The eighth the Effects of the Weather upon other bodies, Thunders, Lightnings, or any thing extraordinary. The ninth general Deductions, Corollaries or Syllogisms, arising from the comparing the several *Phænomena* together.

That the Columes may be large enough to contain what they are designed for, it will be necessary, that the particulars be expressed with some Characters, as brief and compendious as is possible. The two first by the Figures and Characters of the Signs commonly us'd in Almanacks. The Winds may be exprest by the Letters, by which they are exprest in small Sea-Cards: and the degrees of strength by 1, 2, 3, 4, *&c.* according as they are marked in the contrivance in the Weather-cock. The degrees of Heat and Cold may be exprest by the Numbers appropriate to the Divisions of the *Thermometer*. The Dryness and Moisture, by the Divisions in the rim of the *Hydroscope*. The pressure by Figures denoting the height of the *Mercurial Cylinder*. But for the faces of the Sky, they are so many, that many of them want proper names; and therefore it will be convenient to agree upon some determinate ones, by which the most usual may be in brief exprest. As let *Cleer* signifie a very cleer Sky without any Clouds or Exhalations: *Checker'd* a cleer Sky, with many great white round Clouds, such

A
SCHEME
At one View repreſenting to the Eye the Obſervations of the Weather for a Month.

Dayes of the Month and place of the Sun. Remarkable houſe.		Age and ſign of the Moon at Noon.	The Quarters of the Wind and its ſtrength.	The Degrees of Heat and Cold.	The Degrees of Drineſs and Moyſture.	The Degrees of Preſſure.	The Faces or viſible apearances of the Sky.	The Notableſt Effects.	General Deductions to be made after the ſide is fitted with Obſervations: As,
14 ♊ 12.46	4 8 12 4 8 12	27 ♉ 9.46. Perigeu.	W. 2. 3. $2\frac{1}{3}$ W.S.W. 1	9 $\frac{3}{4}$ 12 $\frac{1}{2}$ 16 10 $\frac{1}{8}$ 7 $\frac{1}{2}$	2 5 2 8 2 9	29 $\frac{1}{10}$ 29 $\frac{1}{8}$ 29 $\frac{3}{8}$	Clear blew, but yellowiſh in the N. E. Clowded toward the S. Checker'd blew.	A great dew. Thunder, far to the South. A very great Tide.	From the laſt Q. of the *Moon* to the Change the Weather was very temperate, but cold for the ſeaſon; the Wind pretty conſtant between N. & W. A little before the laſt great Wind, and till the Wind roſe at its higheſt, the Quick-ſilver continu'd deſcending til it came very low; after wch it began to reaſcend, &c.
15 ♊ 13.40	8 4 6 10	28 ♉ 24.51.	N. W. 3 4 N. 2 1	9 8 $\frac{1}{2}$ 7	28 $\frac{1}{2}$ 2 9 2 10	29 $\frac{1}{16}$ 29	A clear Sky all day, but a little Checker'd at 4. P. M. at Sunſet red and hazy.	Not by much ſo big a Tide as yeſterday. Thunder in the North.	
16 ♊ 14.37	10	N. Moon. at 7. 25 A. M. ♊ 10. 8.	S. 1	10	1 10	28 $\frac{1}{2}$	Overcaſt and very lowring.	No dew upon the ground, but very much upon Marble-ſtones, &c.	
		&c.	&c.	&c.	&c.	&c.	&c.		

as are very usual in Summer. *Hazy*, a Sky that looks whitish, by reason of the thickness of the higher parts of the Air, by some Exhalation not formed into Clouds. *Thick*, a Sky more whitened by a greater company of Vapours: these do usually make the *Luminaries* look bearded or hairy, and are oftentimes the cause of the appearance of Rings and Haloes about the *Sun* as well as the *Moon*. *Overcast*, when the Vapours so whiten and thicken the Air, that the *Sun* cannot break through; and of this there are very many degrees, which may be exprest by a *little, much, more, very much overcast*, &c. Let *Hairy* signifie a Sky that hath many small, thin and high Exhalations, which resemble locks of hair, or flakes of Hemp or Flax: whose varieties may be exprest by *straight* or *curv'd, &c.* according to the resemblance they bear. Let *Water'd* signifie a Sky that has many high thin and small Clouds, looking almost like water'd Tabby, called in some places a Mackeril Sky. Let a Sky be called *Waved*, when those Clouds appear much bigger and lower, but much after the same manner. *Cloudy*, when the Sky has many thick dark Clouds. *Lowring*, when the Sky is not very much overcast, but hath also underneath many thick dark Clouds which threaten rain. The signification of *gloomy, foggy, misty, sleeting, driving, rainy, snowy*, reaches or racks *variable, &c.* are well known, they being very commonly used. There may be also several faces of the Sky compounded of two or more of these, which may be intelligibly enough exprest by two or more of these names. It is likewise desirable, that the particulars of the eighth and ninth Columes may be entered in as little room, and as few words as are sufficient to signifie them intelligibly and plainly.

It were to be wisht that there were divers in several parts of the World, but especially in distant parts of this Kingdom, that would undertake this work, and that such would agree upon a common way somewhat after this manner, that as neer as could be, the same method and words might be made use of. The benefit of which way is easily enough conceivable.

As for the Method of using and digesting those so collected Observations; That will be more advantageously considered when the *Supellex* is provided; A Workman being then best able to fit and prepare his Tools, for his work, when he sees what materials he has to work upon.

Saturn.

July 11. Mr. HOOKE's observation on Saturn, made June 29. 1666, was read, and ordered to be registered.

Madrid Correspondence.

July 18. The President communicated a second letter from

the Earl of Sandwich, together with some celestial observations made by his lordship at Madrid, accompanied with a desire of a correspondence in England in making observations.

The President was desired to thank the earl for his respect to the society; and it was ordered, that Mr. HOOKE should give in writing what had been done in England in that matter, and what was intended further; as also that the observation of the late eclipse of the sun should be sent to his lordship; and that Dr. POPE and Mr. HOOKE should join in making observations answerable to those, that were intended to be made in Spain.

Circular Pendulum Applied to a Clock.

The circular pendulum applied to a clock being inquired after, the President affirmed, that he had made trial of one, and observed the motion of it for four days, in which time it had gone so equally with his pendulum-clock, that after those four days were elapsed, he found it only to have gone one minute too fast.

Pendulums and Water-newts.

The experiment with the pendulum and two balls not yet succeeding, it was referred to the next meeting; when also the experiment showing, that a circular pendulum is the same with two pendulums crossing one another was ordered to be made; as likewise that of the water-newts.

Cooling Mixture.

July 25. Some of the members of the society expecting, that the sal ammoniac should cool more potently than the nitre, scrupled the goodness of the sal ammoniac; but Mr. HOOKE affirmed it to be very good. The experiment was tried with bay-salt, but that made the spirit descend from 8½ degrees to 7½ in 5 minutes.

It was ordered, that Mr. HOOKE should privately try the same experiment again, and add some others of the same kind, and give an account of the success at the next meeting.

Circular Pendulum.

An experiment was tried to show, that the circular pendulum is the same with two pendulums crossing one another, and was ordered to be repeated at the next meeting, making the contrivance so, as that the centres might be in the same plane and at a greater distance.

Representation of Compounded Motion of Earth and Moon.

The experiment frequently made to represent the earth's and moon's compounded motion by two balls suspended on a line, being found not to answer expectation, which was to see, whether

the centre of gravity be in the middle of the ellipse, was laid aside.

Experiments Appointed.

The experiments appointed for the next meeting were,

1. The circular pendulum.
2. Experiments with cooling salts.
3. Water-newts.
4. The wheel-saddle.

Madrid Correspondence.

Aug. 8. The President produced another letter of the Earl of Sandwich, dated at Madrid in July, containing his lordship's observations of the late solar eclipse of June 22, together with some others of the moon's bearing. They were read, and referred to Mr. HOOKE.

Comet.

Mr. HOOKE exhibited his observations of the comet in the end of the year 1664, intimating, that he intended to publish them very shortly.[1]

Circular Pendulum.

He produced a certain contrivance to show, that the circular pendulum was made of two straight lines crossing one another.

Minerals for Repository.

There was produced a box of several stones and minerals presented by Sir ROBERT MORAY for the repository, and reduced into order by Mr. HOOKE.

Freezing Mixtures.

Some experiments were tried to produce cold with several salts. Mr. HOOKE affirmed, that he had found, that white salt, vitriol, and alum had not any sensible virtue to refrigerate. Sandiver and potash being tried before the society, it was found, first, that the spirit of wine in the thermometer standing at $\frac{1}{4}$ below one, descended, after the throwing in a quarter of a pound of sandever into the water, one degree in about 5 minutes. Secondly, that the spirit standing at $3\frac{1}{2}$ quarters below one, did, after throwing in a quarter of a pound of potash into $\frac{1}{4}$ of water, rise above $\frac{3}{4}$ of a degree in 4 minutes.

Pendulums and Water-newts.

Mr. HOOKE was ordered to prosecute at the next meeting the

[1] They are published among his *Lectures and Collections*, at London, 1678, in 4to. See p. 490.

circular pendulum; and also to show his new watch, affirmed by him to be more exact than any pendulum-watch; and to produce some water-newts for the experiment appointed before.

Circular Pendulum.

Aug. 15. The contrivance for the experiment appointed to show, that the circular pendulum was made of two straight lines crossing one another, being fitted, as was suggested at the preceding meeting, it appeared, that the motion from the one end of the greater diameter of the circular pendulum to the same end again was equal to two vibrations of the straight line pendulum, equal in length to the former, and moving in the same plane.

Hooke's Tasks.

A list being read of those particulars, which, since the society's resuming of their meetings, had been recommended to the care of the several members; it was ordered, that every one of them, according as they appeared at the meetings, should be put in mind of their several tasks; . . . Mr. HOOKE, of perfecting his new quadrant; of producing a new sort of watch more exact than a pendulum-watch; of observing the parallax of the earth's orb; of prosecuting the magnetical experiments, first for finding out whether gravitation be something magnetical; and then whether the magnet will attract at the same distance in water, as in air; as also whether the lines of a loadstone's direction are truly oval.

Experiments Appointed.

The experiments appointed for the next meeting were:

1. The circular pendulum to be prosecuted. 2. The new watch to be produced. 3. Some water-newts to be provided.

New Watch.

Aug. 22. Mr. HOOKE was desired to bring in at the next meeting his new watch, which he formerly mentioned to be exact as a pendulum.

Circular Motion.

He was ordered to observe, whether the circular motion be compounded of sines.

Leaping Cheese-maggots.

Mr. HOOKE remarked, that he had observed with a microscope, how the leaping cheese-maggots put their tail into their mouth, and when they leap, spring it out with great force, to leap a great way like fleas.

Reflecting Instrument.

Mr. HOOKE mentioned a new astronomical instrument for making observations of distances by reflection, and was desired to give order for the construction of it, and to produce it before the society.

Limpets.

He remarked, that he had observed a kind of shell-fish, called limpets, to make holes in rocks of the sea above an inch deep, just of the bigness of their shell, which was of the figure of a snail.

Watch-work.

Aug. 29. Mr. HOOKE produced also a new piece of watch-work of his contrivance, serving to measure time exactly both by sea and land; of which he was ordered to bring in the description.

Reflecting Instrument.

He mentioned again a perspective, which he was preparing for observing the positions and distances of fixed stars from the moon by reflection; and was desired to have it made with speed, and to bring in the description of its structure and uses.

[Undated. ? *c.* 1666]

LETTER FROM HOOKE FOR HEVELIUS

Sir,

I thank you very much for the opportunity you have given me of being in any ways serviceable to a person, who has so highly obliged the learned world, as the excellent Hevelius has, both by the curious and learned pieces he has already published, and by those other great undertakings, which he has given them cause to hope for and expect from his indefatigable endeavours. And in truth, sir, upon the consideration of the subject he has designed, I being ignorant of what instruments he makes use, and of what help that northern climate affords for that purpose, I have often wished that he were furnished with as good optic glasses, as are now in use in other parts of the world, and with some good method of making use of them for determining the diameters and parallaxes of the planets, and for finding the positions and distances of the smaller fixed stars, &c. For then I could not doubt to receive, from his judgment and diligence in the use of them, better effects than what have been hitherto produced by others. And in particular I have wished that those sextants, at least, he

makes use of for measuring the distances of stars, were furnished with telescopical sights, which is no small advantage for regulating and assisting the sight, which if he desires it, I shall be most ready to gratify him with any information, that the small experience I have in those things will furnish me with.

The largest glass I have several times made use of, is a spherical lens, convex on both sides, of a sphere whose radius is 60 feet, and the focus or length of the glass is near about the same length; 'tis made of a piece of glass of between $\frac{1}{4}$ and $\frac{1}{2}$ inch thick, and between 5 or 6 inches over; it bears an aperture of about 3 inches, sometimes 4 or more, according to the uses I design it for. It discovers many things not visible through a very good 36 [foot] glass; such as the shadow of the satellites, and the verticity of Jupiter and Mars on their axes. Some make use of two convex eye glasses, but I for the most part make use but of one, and that a very deep convex lens: convex on both sides of a sphere of   inches radius. Sometimes I use such as are more shallow, but seldom any deeper. The method, by which that I have was made, was by the ordinary way in a very deep dish, and wrought on the tool by the hand without any kind of engine, till such time as it be exceedingly bright and well polished, and have received the perfect figure of the scutella, in which it was wrought, (otherwise the glass will be worth nothing,) in the doing of which there is great difficulty.

The tube I make use of is about 66 or 68 feet in length,[1] and consists only of two long square boxes or tubes made of very thin and light slit deal, here and there bound together with very thin plates of iron, under which, within the tube, there are placed several square portions or cells of the form A, which serve to keep off the adventitious rays, and to keep the sides of the tube square and steady. Each of these boxes is about 10 inches square, and about 33 feet long: these two are thrust into a small square box B, in the middle about 2 or 3 feet long, made of thicker boards bound about with iron, and having two long boards CC fixed to them of about 6 feet high, and joined at the top by a piece D interjacent between them, over the top of which there is afterwards stretched a rope that serves to set the tube straight, and to keep it from warping, the manner of which will be easily

[1] See figure on p. 197.

understood by the figure adjoining, F a little cylinder, on which the end of the long rope FE is rolled, thereby to shorten or lengthen it, according as the bending of the tube in the middle requireth; GG another smaller cord wound about the former rope and the tube, by the stretching or slackening of which the two parts of the tube are reduced to a straightness as occasion requires.[1]

This being done, the whole machine is hung by a handle, after the manner of a pair of scales, the two ends of the tube near equally counterpoising each other, and by that handle it is drawn by a tackle up to any height desirable by the strength of one man only: the whole tube not weighing at most above 200 pounds weight, and when up 'tis manageable with the greatest facility imaginable.

I have inquired the lowest rate any such object-glass will be sold for, and find it will not be afforded for less than £25 sterling, and the eyeglasses will cost 40*s.* or 50*s.* more. If Mr. Hevelius desire any, upon his signifying his mind to me, I shall endeavour to get him the best that can be made here, and at the lowest rate.

Sept. 9.

(14) *Observations made in [London] of the late Eclipse of the Sun, which hapned on the 22 of June 1666.*

Phil. Trans., xvii, pp. 295–6, September 9, 1666.

Reflecting Instrument.

Sept. 12. Mr. Hooke presented his new perspective for taking angles by reflection; which was approved of by the society, and he was desired to bring in the description of it in writing.

Discussion of the Effects of the Great Fire.

The society being taken up for the most part of this meeting with the consideration of the place for their future meetings in that time of public disorder and unsettlement by reason of the late fire, was thereby hindered from making experiments, and discoursing of philosophical subjects, as they used to do.

Model of City of London.

Sept. 19. Mr. Hooke showed his model for rebuilding the

[1] The passage, from 'F a little cylinder,' to 'occasion requires,' is not, like the rest, in Hooke's, but in Oldenburg's handwriting. The letters in it are not found on the original figure, but have been now inserted to answer to the description of it.

(Rigaud, *Correspondence*, p. 179.)

city to the society,[1] who were well pleased with it; and Sir JOHN LAURENCE, late Lord Mayor of London, having addressed himself to the society, and expressed the present Lord Mayor's and Aldermen's approbation of the said model, and their desire, that it might be shown to the King, they preferring it very much to that, which was drawn up by the surveyor of the city; the President answered, that the society would be very glad, if they or any of their members could do any service for the good of the city; and that Mr. HOOKE should wait on them with his model to the King, if they thought fit to present it: which was accepted with expressions of thanks to the society.

Transfusion of Blood.

Sept. 26. There was read a description of the method of transfusing the blood of one animal into another, as it had been practised with success at Oxford by Dr. RICHARD LOWER; which description was communicated by him in a letter to Mr. BOYLE. It was ordered to be registered, and Mr. DANIEL COXE, Mr. THOMAS COXE, Mr. KING, and Mr. HOOKE were appointed to be curators of this experiment, first in private by themselves, and then, in case of success, in public before the society; and Dr. GODDARD, Dr. MERRET, Dr. CLARKE, Dr. CROONE, and Dr. BALLE were desired to be present at the experiment.

Jupiter's Satellites.

Oct. 3. The Lord Bishop of Exeter being requested to communicate the observations of Jupiter's satellites made by Mr. LAURENCE ROOKE, in order to the calculating of tables of their motion, his lordship desired, that he might be put in mind of it by Mr. HOOKE, and that he would purposely come to his library in Gresham College to look them out.

[Perhaps the observations made on 7 May and 20 May by Dr. ROOKE in MS. Sloane, 1039, f. 140, were intended.]

Hooke's Salary.

Oct. 29. It was ordered, that the journal of the society be perused by the Secretary, to find out what had been formerly ordered concerning the payment of the thirty pounds per annum to Mr. HOOKE.

[1] Mr. WALLER in his life of Dr. HOOKE, p. 13, prefixed to his *Posthumous Works*, remarks, that he could not well determine what that model was, but had heard, that it was designed in it to have all the chief streets, as from Leadenhall Corner to Newgate, and the like, to lie in an exact straight line; and all the other cross-streets turning out of them at right angles; all the churches, public buildings, market-places, and the like, in proper and convenient places: which no doubt would have added much to the beauty and symmetry of the whole.

Brick Earth.

Oct. 31. Mr. HOOKE took notice, that those earths, which will vitrify, make the more lasting bricks.

It was ordered, that Mr. HOOKE should make trials of several earths by burning them in a wind-furnace, to see, which kind would yield the best brick.

Madrid Observations.

The papers containing observations made at Madrid were delivered to Mr. HOOKE to peruse them, and make a report of them to the society. To which was added a little scheme made by the President.

Inclining Pendulum.

Mr. HOOKE produced an inclining pendulum, which, though short, should perform the office of a long perpendicular one, the several degrees of inclination answering the several dimensions of length. It was ordered, that the trial of it should be prosecuted at the next meeting.

Salary Due to Hooke.

Nov. 5. It was ordered, that the business of the moneys, pretended to be due to Mr. HOOKE, be deferred till Dr. WILKINS's return; and that in the meantime all the orders ordered in the journals relating to the same be looked out and produced upon occasion.

Soundings.

Nov. 7. Mr. HOSKYNS suggested, that it might be inserted among the directions for seamen, to fetch up the several sorts of earth from the bottom of the sea.

Mr. HOOKE was ordered to think upon and provide an easy instrument for that purpose.

Inclining Pendulum.

The inclining pendulum being again spoken of, it was ordered, that it should be fitted by Mr. HOOKE against the next meeting for all inclinations, to bring it at last to rest.

Nov. 14. The experiment of the inclining pendulum was repeated, and Mr. HOOKE was ordered to bring in a scheme of it, and a description of its uses.

Chariot.

Col. BLOUNT gave an account of the improvements of his chariot; how he had made his springs five double on each side, and thereby freed it from tossing; suggesting, that if Mr. HOOKE's springy-saddle should do well, the springs of it must be doubled.

Coccothraustes.

Mr. AUSTEN produced from Dr. CHARLETON a bird called *Coccothraustes*, together with the Latin description thereof out of BELLONIUS; which new bird was committed to Mr. HOOKE for the repository, and the description ordered to be filed up.

Nov. 16. "This noon met Mr. HOOKE, who tells me the dog which was filled with another dog's blood at the College the other day is very well, and like to be so ever, and doubts not its being found of great use to men, and so Dr. WHISTLER, who dined with us at the tavern." PEPYS *Diary*, 1666.

Inclining Pendulums.

Nov. 21. Mr. HOOKE's account of inclining pendulums was read, and ordered to be registered, as follows:[1]

There are two things chiefly to be considered in the motion of a pendulum; the one is the velocity of the motion in each vibration, and the other is the equidiuturnity or equality of duration of the vibrations of the same pendulum, though of very differing arches.

As to the first, the determination of the velocity of the vibration depends on the proportion between the quantity of strength, and the bulk of the body to be moved; wherever the proportion of strength is greater to the proportion of the bulk, there the motion is swifter, and where less, there slower. In all pendulous motions, the strength moving is gravity, and that is more or less, according as it moves the body more directly or obliquely towards the centre of the earth.

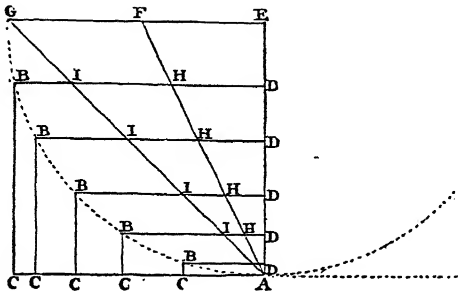
As to the second consideration, the equality of duration of vibrations of differing arches or lengths depends upon the figure of the curve line, in which the body is moved; which figure being for a great part very near the same with that of a circle, it follows, that the motion in differing arches of the same circle will be very near of equal duration.

Now this equation depends on the proportion of the length of the intercepted arches to the length of the perpendicular lines of attraction terminating those arches, that is, (to avoid multiplicity of defining words) on the proportion between the lengths of AB, AB, AB, to the lengths BC, BC, BC, &c. Now, if those proportions be, as of a series of roots, to a series of squares, the vibrations of differing arches shall be of equal duration. Now the proportion of arches to the bounding perpendiculars, or (which is all one) to the corresponding versed sines, being very near the same, the vibrations in differing arches of the same pendulum are very near of an equal duration.

[1] R. S. MS. No. 44.

This being premissed, I say, that the vibrations of an inclining pendulum in differing arches shall be very near also of equal duration: For in all circular motions in an inclining plane, the proportion of the intercepted arches to the perpendiculars shall be very near, as of a series of roots to a series of squares: Or, which is sufficient to our present purpose, the intercepted perpendiculars shall be to one another, in the same proportion with that of the versed sines of those intercepted arches: therefore the vibrations must necessarily be of an almost equal duration.

Let FA or GA represent the inclination of an oblique pendulum, it is evident, that the parts FH, FH, FH, &c. are to FA,



and GI, GI, GI, &c. to GA, as ED, ED, ED, &c. to EA. But these are in proportion, as the sine-complements of arches increasing by an arithmetical proportion, from the lowest point A: therefore the arches corresponding to the aforesaid divisions of AF and AH, shall be in arithmetical proportion, and consequently also, the perpendiculars from those points H, H, H, &c. and I, I, I, &c. to the horizontal line AC, shall be the same with the lines AD, AD, AD: That is the perpendicular lines of gravitation or attraction answering to the several arches in an inclined plane, shall be to one another, as the perpendicular lines of attraction or gravity are to one another in a perpendicular pendulum, which was to be demonstrated.

How to determine the time, according to the several inclinations, I shall demonstrate in my next.

Short Pendulum.

Mr. Hooke showed the society another kind of pendulum, which being perpendicular and short, by counterpoising performed the part of a long one.

The President was of opinion, that the circular pendulum, as far as he yet saw, was the best of all kinds, of which he had hitherto made trial.

Bubble Level.

Nov. 28. Mr. Hooke produced a new kind of level, by including a large bubble of air in a glass pipe, having its sides exactly blown, and filled with water, and sealed up at both ends. He was ordered to bring in its description and manner of application to practice.

New Backstaff and Earth Auger.

He produced likewise a new kind of back-staff for taking altitudes; as also an auger or instrument to take up earth with; of both which he was also ordered to give in a description and the manner of using them.

Eggs of Ray.

Mr. Hooke produced a substance, which he called the eggs of a ray-fish: Which and the other presents were ordered to be put into the repository.

New Watch and Optic Glasses.

The experiments appointed for the next meeting were a new kind of watch, and optic-glasses upon new principles, to be produced by the curator Mr. Hooke.

Money Due to Hooke.

Dec. 4. Dr. Wilkins moved, that Mr. Hooke might be considered as to the payment of some money, which he thought due to him from the society. But the orders concerning that business not being yet extracted out of the journals, it was referred to the next meeting of the council.

Wren's Level.

Dec. 5. Sir Robert Moray mentioned a new kind of level contrived by Dr. Christopher Wren, which Mr. Hooke was ordered to get made as soon as he could; adding to it the way to determine, how much it varied from the level.

New Pendulum.

Mr. Hooke produced a new sort of pendulum made after the manner of a beam, and so contrived, that by placing the beam nearer or farther below the centre of motion, the pendulum may perform its vibrations in any time assigned; in which he affirmed to be one certain depth, beyond which the pendulum would not go quicker, which he had not yet reduced to a theory, but hoped to do it.

Sea Bucket.

He having mentioned likewise his contrivances of two instru-

ments, the one for fetching up earth from the bottom of the sea, the other for fetching up the several sorts of earth out of the ground on the land, was ordered to get them both made with speed.

Experiments Appointed.

The experiments appointed for the next meeting were,

1. The bleeding of sheep into a dog; the curators of which were to be Dr. POPE, Dr. KING, Mr. COXE, and Mr. HOOKE, who were to perform it first by themselves in private.
2. Mr. HOOKE's new principle of making optic-glasses.

Transfusion of Blood.

Dec. 12. The experiment, which was ordered of bleeding a sheep into a dog of the kind of curs was made; which succeeded pretty well, though not so well as that, which had been made at the meeting of November 21, by reason, as it was supposed, of the frosty weather causing more coagulation in the blood. In the meantime Dr. KING reported to the society, that on the Monday before, the like experiment had been tried in private with very good success, at which were present Dr. POPE, Mr. DANIEL COXE, Mr. THOMAS COXE, Mr. OLDENBURG, and Mr. HOOKE.

It was ordered, that at the next meeting this experiment should be tried upon a mangy and a sound dog, letting the blood of the former into the veins of the latter; and that Dr. BALLE, Mr. DANIEL COXE, Mr. THOMAS COXE, and Mr. HOOKE should take care of the experiment.

Wren's Level.

Dr. WREN's level being called for, it was produced ready-made, and ordered to be described.

New Clockwork and New Bucket for Dredging.

Dec. 19. Mr. HOOKE proposed a new clock-work, and a new bucket to fetch up earth from the bottom of the sea, and promised to bring them in both at the next meeting.

Optic Glasses.

He was also put in mind of his new way of making optic-glasses, formerly proposed by him.

Transfusion of Blood.

It was ordered, that at the next meeting the experiment be made of transfusing the blood of a sound dog into a mangy one; and that the operator provide necessaries for it, to begin the operation about twelve o'clock that day.

Tide in Solent.

Mr. Hooke took notice, that he had observed, that between Portsmouth and the Isle of Wight from half-flood to high-water, and so to half-ebb, it runs from west to east, and again from half-ebb to low-water, and so to half-flood again, it runs from east to west.

Arrears of Salary.

Dec. 21. That the accounts concerning Mr. Hooke be stated by the Treasurer, that it may appear what the former had already received, and what yet remained due to him, according to the several orders formerly made by the council; and that thereupon the Treasurer pay Mr. Hooke what should thereby appear remaining due to him.

The Cutler Foundation.

That Mr. Hooke be desired to promise by his handwriting to observe the ends, for which the report from Sir John Cutler entered in the journal-book of the society, November 9, 1664, affirms the fifty pounds a year to be given him by Sir John: and

That the President be desired to draw up a form for such a promise to be subscribed by Mr. Hooke.

1666/7

Bucket for Sea Bottom.

Jan. 2. Mr. Hooke brought in the formerly proposed bucket for fetching up earth or any other solid body from the bottom of the sea. It was ordered, that care should be taken so to fit it, that the springs might go off both together, and that easily and certainly, and when it meets with soft ground, as well as hard; as also to grate it over.

New Clockwork and Circular Pendulum.

He likewise brought in a new clock-work, so regulating and adjusting a circular pendulum, that at the end of a certain number of vibrations, the clock-motion should be reduced to an exactness, which it had not before. He was ordered to perfect it, and to bring in a full description of its structure and use in writing.

Transfusion of Blood.

It was ordered, that the experiments of transfusing blood be prosecuted, when the summer weather came in.

Experiments Appointed.

The experiments appointed for the next meeting (besides the perfecting of the two instruments above mentioned) were:

1. A new kind of weather-glass, to try all degrees of heat in, viz. what degree will melt such and such bodies.

2. An instrument to apply the strength of powder to the bending of springs securely and certainly, both by Mr. HOOKE.

Arundel Library and Extracts of the Journals.

Jan. 4. It was ordered, that Mr. HOOKE be on a committee for causing a catalogue to be made of the library of Arundel house, and that he attend Dr. WILKINS about reducing the extracts of the society's journal-books into a method for Mr. SPRAT.

Diameters of Planets.

Jan. 9. Dr. WREN and Mr. HOOKE having related to the society several ways, which they had known long before, of taking the diameters of the planets to seconds, were desired briefly to describe them, that so it might be signified to the Parisian philosophers, that it was a thing not at all new among the English.

Parallax.

Mr. HOOKE renewed his former proposal of observing the parallax of the earth's orb; which he was exhorted by the President to do with all convenient speed.

Sea Bucket.

There was again produced the bucket for fetching things from the bottom of the sea. It being not yet altered, as had been directed at the preceding meeting, it was ordered to be perfected against the following one.

New Clock.

The new clock-motion for adjusting the circular pendulum was also ordered to be perfected against the next meeting.

Plastic Metal.

Jan. 16. Mr. HOOKE showed a metal, which he said was a preparation of mercury fit to take off any impression of a seal or medal, &c. and to enlarge or lessen the same, keeping its proportions, and then to grow hard again after two or three hours' time. He tried it before the society with some success, by softening the hard metal with the pressure and working of a knife, and by taking off impressions. He was desired to perfect the experiment.

Laws of Motion.

It was mentioned by Mr. OLDENBURG, that the council had thought fit, that the experiments for making out a theory of the

laws of motion formerly begun by Dr. WREN, Dr. CROONE, and Mr. HOOKE; as also those about the magnet formerly begun by Mr. BALLE and Mr. HOOKE, should be prosecuted. The society hereupon desired Dr. WREN to give in those experiments of motion devised by himself; but he alleging, that the account of them was at Oxford, Dr. CROONE and Mr. HOOKE were desired to bring in theirs; as also, that Mr. HOOKE should prosecute the experiments of the loadstone.

Diameters of Planets.

Dr. WREN and Mr. HOOKE were again desired to communicate their methods of taking the diameters of the planets to seconds.

Experiments Appointed.

The experiments appointed for the next meeting were:

1. To have perfected the circular pendulum lately exhibited:

2. The engine for applying gunpowder to the bending of springs:

3. To have the bucket for fetching up of things from the bottom of the sea completed.

Hooke's Promise as Cutlerian Lecturer.

Jan. 17. It was ordered, that the form, drawn up by the President, of the promise to be made by Mr. HOOKE for observing the ends, for which (according to the report of November, 9, 1664) the fifty pounds per annum were given him by Sir JOHN CUTLER, be delivered to the said Mr. HOOKE; which was accordingly done. The form was as follows:

Whereas upon consideration, that Sir JOHN CUTLER, knight and baronet, hath settled upon me fifty pounds per annum during my life, I have promised and undertaken to read in the vacation times in Gresham College, or in such other place, as the Royal Society shall meet in, sixteen lectures per annum, in order to the advancement of art and nature, the said society having been desired to direct the particular matter of the said lectures by reading one, each week, during the so many weeks successively, next after each of the four usual terms in the year, as were weeks in the then last preceding term, upon such day of each week, as the said Royal Society shall meet upon; I do hereby renew the said promise, and undertake to read the said lectures upon such particular matters, as the said society shall direct. In testimony whereof I have hereunto set my hand and seal.

It was ordered, that a copy of the said report, as also of the thanks, that were to be returned to Sir JOHN CUTLER, be forthwith made and delivered to Sir ROBERT MORAY or Sir PAUL

NEILE, to give it the Lord Bishop of EXETER, to show it to the said Sir JOHN CUTLER, that he might declare, whether it was really his intention to instruct the society with the management of the fifty pounds given by him to Mr. HOOKE.

Hevelius v. *Auzout.*

Jan. 23. Mr. HOOKE was ordered to bring in something in writing relating to the controversy between Mr. HEVELIUS and Monsieur AUZOUT, which might import, that upon examination of the observations made in England, and compared with those made in other parts, the society was inclined to believe, that Mr. HEVELIUS had been mistaken.

Altitude Measurements.

Mr. HOOKE affirmed, that the altitude of the sun or other stars might be taken with a single six-foot telescope put perpendicular, without any refraction or parallax, and that in the space of two or three minutes: which was ordered to be tried, and the success and way of doing it to be registered.

Measurement of Circumference of the Earth.

He affirmed likewise, that the circumference of the earth might be measured to seconds by a sixty-foot glass put perpendicular, a place being given, where the distance may be conveniently measured, such a one as may be smooth and a mile long, lying north and south, or at least north-east and south-west. He was ordered to make this experiment as soon as a place could be found convenient for it.

Sea Bucket.

The instrument for bringing up things from the bottom of the sea being again mentioned, Mr. HOOKE took notice, that this, as it then was, having been tried, could bring up things only from a small depth; but that he would try other ways for greater depths.

Venus.

He affirmed, that Venus had lately appeared to him in a twelve-foot glass as big again as the moon to the naked eye; adding, that he never saw her so sharp, and that she was very near the sun, with whom she would be in conjunction within a very few days.

Cutlerian Lectures.

Jan. 25. Mr. HOOKE delivered to the council a paper signed and sealed by him, containing a renewal of his promise and undertaking of reading sixteen lectures a year upon such particular matters, as the society shall direct.

Cutlerian Lectures.

Feb. 1. That Mr. HOOKE prepare himself to read before the society in Arundel House at their next meeting-day after this present term.

New Lamp.

Feb. 6. Mr. HOOKE produced a new kind of lamp serving to supply the oil in due quantity, so that as it wastes, there may not rise too much or too little, by a weight, that should always counterpoise the oil, the figure being a half-cylinder. The description and demonstration of it were ordered to be brought in by him, as soon as conveniently he could.[1]

It was likewise ordered, that this vessel should be so prepared for the next meeting, that it might actually serve for a lamp, as it was designed.

Gunpowder for Raising Weights.

The experiment for raising a weight by the force of gunpowder was tried, but the weight was thrown off, instead of being raised.

It was ordered, that Mr. HOOKE should think of a way to make it succeed; as also, that he should prosecute the experiment of winding up a spring the same way.

Expansion of Powder.

Mr. BOYLE desiring, that the expansion of powder might be examined, it was ordered, that Mr. HOOKE should consider of and draw up such experiments, as might be proper to examine the said expansion.

Money Due to Hooke.

Feb. 14. It was ordered, that the Treasurer pay Mr. HOOKE what appeared to be due to him, upon the balance of his account, now presented, which was as follows:

The account of moneys due to Mr. ROBERT HOOKE, as Curator to the Royal Society, is debtor

	l.	*s.*	*d.*
To the first payment of 80 l. per annum, due to him at Midsummer 1664	20	0	0
To the second quarter's payment due at Michaelmas 1664 .	20	0	0
To money due upon the said account of 80 l. per annum from Michaelmas 1664 to the 23rd of November following .	11	13	4
To money due to him by an order of the 23rd of November 1664, at 30 l. per annum to 23rd November 1665 . .	30	0	0
To money due more upon the said order from the 23rd of November 1665, to Christmas 1666	32	10	0
	114	3	4

[1] The description of this lamp is published in his *Lampas*, printed at London, 1677, in 4to.

The said account is creditor

By moneys received by Mr. Hooke of Mr. Hill on account of the 80 l. per annum	39	0	0
By money received of Mr. Colwall per order . .	30	0	0
By the balance resting due to Mr. Hooke, which the Treasurer is hereby ordered to pay	45	3	4
	114	3	4

It was ordered, that the payment of Mr. Hooke for the future be considered of at the next meeting.

Gunpowder for Winding a Spring.

The experiment of winding up a spring by the force of gunpowder was made by Mr. Hooke; and the success, as he related it, was, that about a grain and a half of powder wound up a spring to the top, which was about four feet high. It was ordered to be tried again at the next meeting.

Experiments Proposed.

Mr. Hooke proposed for the next meeting (besides the particulars mentioned above, relating to the addition to the lamp, and the repeating of the experiment of winding up a spring by gunpowder) an experiment improving circular pendulums, by so ordering them, that they shall not vary their motion by more or less appendant weight; which he also undertook to demonstrate.

Circular Pendulum.

Feb. 21. Mr. Hooke produced a circular pendulum so contrived, that its motion should be equal, whatever weight was appended to it. He affirming, that he knew the demonstration of it, was ordered to give it in writing at the next meeting.

He was ordered likewise to compare the motion of this circular pendulum with a clock: And

New Lamp.

To bring in the description and demonstration of the new lamp, as also to prosecute and improve the experiment of raising weights by the force of gunpowder to a greater height.

The operator was again ordered to attend Dr. Wren to receive his directions for the making his new kind of lamp, and for the addition to Mr. Hooke's lamp mentioned at the preceding meeting.

Variable Star.

As to the other star in the girdle of Andromeda, which Monsieur Bullialdus thought to appear and disappear by turns, as those

in the necks of the whale and the swan, Mr. HOOKE affirmed, that he had seen it this winter, and several times in the years 1664 and 1665. He was desired to observe carefully both these phenomena.

Short Telescope.

Feb. 28. Mr. HOOKE produced a box with optic-glasses fitted in it, designed to contract the power of a long telescope into a short one.[1]

It was ordered, that the eyeglass should be made to draw, and that the two steel glasses should be truly ground, well polished, and exactly placed.

Circular Pendulum.

The circular pendulum designed for an equal motion with unequal weights being again spoken of, the President affirmed, that though the inventor Mr. HOOKE had demonstrated, that the bullet of the circular pendulum, if it can be always kept rising or falling in a parabola, will keep its circular motion in the same time; yet he had not demonstrated, that the diameter of the parabola from the point of contact in the curve to the vertex of the diameter is equal to that portion of the curve from the said point of contact to the vertex of the same curve, plus half the *latus rectum* or plus double the focus of the parabola.

New Lamp.

Mar. 7. The lamp was again produced, having for a wick a small thread of lead thrust through the midst of cottons, which melted as the cotton burnt.

Metal for Polishing.

Mr. HOOKE mentioned a metal, that might be ground with sand, and polished with putty; which was ordered to be put in execution.

New Lamp.

Mr. HOOKE was ordered to bring in writing at the next meeting his demonstration of the motion of his new lamp; and likewise the demonstration of the curve line in his circular pendulum.

Mar. 14. Mr. HOOKE brought in the description and demonstration of his new lamp;[2] which was ordered to be registered, as follows:

Let the vessel be made of brass, tin, wood, or the like, of a

[1] This is described in his treatise of *Helioscopes*, printed in 1676.

[2] The original sketches for this Lamp are in R. S. MS. No. 33. See also No. 47.

semi-cylindrical, hemispherical, or any rounded figure, placing the axis of that figure exactly horizontal, and leaving the upper part open. Then fit into it another semi-cylinder, hemisphere or like fashioned body, to the containing vessel of brass, wood, or any other material, which will be capable of being made lighter by half, than so much of the oil, as is equal to it in bulk. Let the two ends of the axis of this semi-cylinder terminate in two

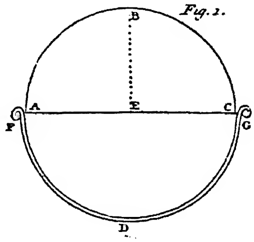


Fig. 1.

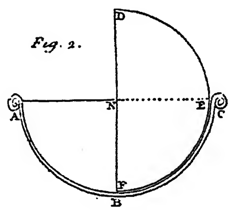


Fig. 2.

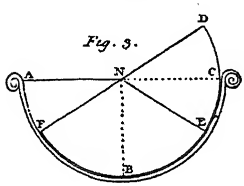


Fig. 3.

several pivots, and let the containing vessel have likewise two small holes in the centres of each end, into which let the pivots be fitted, and so ordered, that it may freely pass and turn round within the hollow of the containing vessel. On some part of the side of this containing vessel make a small socket, so that the hole of it, where the flame is to be, may be a little above the plane, that passeth through the axis. Then pour your oil into the containing vessel, and the counterpoising semi-cylinder shall always keep the surface of the oil of equal height with the horizontal plane, that passeth through the axis of both semi-cylinders.

Suppose it first perfectly filled to the horizontal plane; then it

is evident, that, the whole solid semi-cylinder being about the oil, the one half of it will counterpoise the other, and so neither can have any pressure upon the oil.

As in the first figure, let FDG represent the containing vessel, filled to the line FG with oil; and ABC the solid semi-cylinder, equal in weight to half as much oil as is equal to it in bulk: then it is evident, that the quadrant AEB will counterpoise the quadrant BEC, and neither side press on the oil.

Next, suppose it only to contain oil enough to fill half the semi-cylinder; and let ABC in the second figure represent the containing vessel, DEF the solid counterpoise, and ANB the oil; it is evident the two solid quadrants DNE and ENF, being each of them half the weight of the oil, and in the same position, must counterpoise the quadrant of oil ANB.

Thirdly, supposing it to contain any other quantity, less than will suffice to fill the vessel to the horizontal plane, that passeth through the axis, the same will follow, as in the third figure; let ANF represent the wedge of oil, and DEF the solid semi-cylinder: I say, the semi-cylinder shall, in this posture also, counterpoise the oil in the vessel. Make CNE equal to DNC, then shall FNB and BNE be equal, and consequently counterpoise each other. Next, CNE being equal to DNC; and DNC to ANF, it follows, that the wedge of liquor ANF shall be counterpoised by two equal wedges, each of half the weights DNC and CNE. The like may be demonstrated of any other quantity of oil whatsoever, less than will fill the vessel to the horizontal plane, and more than will fill the space, necessary to be left between the concave and solid cylinder.

Clock and Sundial.

Mr. Hooke produced likewise a contrivance to make a motion of a clock to go along with the shadow on a wall, for which he offered a demonstration; affirming withal, that the same instrument would be applicable to all planes to make all sorts of dials; and that upon the same principle he would make an instrument to solve the inequality of days both from the sun's eccentricity and his right ascension upon the elliptical as well as circular hypothesis.

Experiments Ordered.

Mr. Hooke was ordered

1. To prosecute the experiments of raising a weight, and bending a spring, by the force of gunpowder.

2. To make experiments with Dr. COTTON's loadstone.

3. To perfect the instrument for taking up things from the bottom of the sea.

4. To bring in the demonstration of the curve line, that shall so regulate the motion of the circular pendulum, as to make it go equally with unequal weights.

Contracted Telescope.

Mar. 21. Mr. HOOKE produced again his new kind of contracted telescope of two feet long, performing the part of a six-foot glass by the means of two reflections. He was ordered to bring in the description of it, and to try it upon nocturnal objects; as also to have ready for the next meeting a six-foot glass to compare it with, and to change the object glasses.

Smethwick's Achromatic Glass.

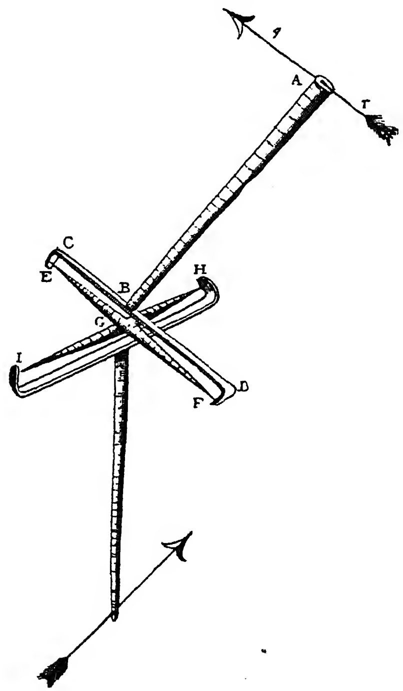
Sir PAUL NEILE was desired to encourage Mr. SMETHWICK, the inventor [of a glass wherewith they saw an object without any considerable colours], and he intimated, that he had advised him to apply himself to Mr. HOOKE for assistance.

Dialling.

Mr. HOOKE brought in the description of a very easy and simple but universal instrument to describe all kinds of plane dials, together with a demonstration of the principles and reason of it: Which was ordered to be registered, as follows:

Unto the end of a very straight and stiff steel wire, as AB, fasten at one end an index at right angles with it, as *qr*, and at the other make a pair of forked arms, as CD, having two small centre-holes, at each end one, as at E and F, between which, if a right line be drawn, (as EF) it shall pass both through the axis of the wire AB, and likewise be at right angles with it. This done, make another wire of the same material, and in all other particulars exactly the same with the former; then make a cross of steel EFGHI, sharpening all the four corners EIFH into very sharp and small-pointed pivots, and make all the arms of the cross exactly at right angles with one another; and the length of each arm from the point of intersection exactly half the distance between E and F. This done, join the two steel wires (formerly described) together, by the cross, by putting two of the opposite pivots into the centre-holes of the arm of the one wire: the two other opposite pivots into the pivot-holes of the arms of the other wire, which may be easily done, if those arms are made a little springing: then, by any convenient contrivance (of which there may be multitudes, as by a frame, or staples upon a movable screw, &c.) so order these wires, that one of them may lie in, or

parallel to, or at least in the same plane with the plane of the stile; and with the same inclination to, or angle with the plane of the dial, with the inclination or angle of the axis and plane of the dial. And that the other arm may lie at right angles with, or perpendicular to the plane of the dial, then shall the moving of the index of the wire in the axis, equal spaces, cause the index of the perpendicular wire to move unequal spaces, according to



INSTRUMENT TO DESCRIBE PLANE DIALS.
(*Hooke's original Sketch is preserved in R. S. MS. No. 31.*)

the proportions of the shadows. If therefore the wire of the axis be moved by an exact clock, once round in 24 hours, or the space of time between the sun's leaving a meridian, and returning again to the same, the index of the other wire shall move on the plane of the dial, to which it is adapted, in the same velocity with the shadow of the sun in that plane. The reason of all which is most evident, for if a plane be supposed to pass through the axis of the stile, and to be turned round upon that axis with equal velocity once in 24 hours, it is evident, that if at the beginning of its motion, that plane pass through the centre of the sun, it

shall also continue to pass through the same centre, for its whole revolution; and consequently, that part of the plane, which lies on the other side of the axis, opposite to the sun, shall always be in the shadow of the axis; and consequently, the lines of the intersection, of this moved plane, with the plane of the dial, shall give the respective lines of shadow appropriate to that plane. But it is evident, from the contrivance of the newly described engine, that those branches of the cross whose pivots are centred in the arms of the wire in the axis, do always move round the axis in the same plane, and consequently move equal spaces in equal times. And it is likewise evident, also, that the other branches of the cross, do always move both in a plane at right angles with the former plane, and consequently move also about the axis equal spaces in equal times; and also in the plane of the dial; and consequently must always lie in the line of the intersection of the plane through the axis with the plane of the dial, and must therefore always move, in the shadow of the axis, according to the several velocities of the shadow, unequal spaces in equal times.

The application of which instrument to the use of describing all sorts of dials is so very evident, that I think I need not further explain it: For if the index of the axis be moved, to the equal divisions in a ring about it of hours, quarters, minutes, &c. the index on the wire perpendicular to the plane of the dial will point out the respective unequal divisions on that plane. The use of this mechanical principle for equation of time, resolving triangles, raising water, facilitating wheel-work, and several other mechanical uses, I may hereafter show.

Mr. HOOKE affirming, that upon the same principle he could frame an instrument to indicate the inequalities of the days, was desired to cause such an instrument to be made.

Loadstone.

Mr. HOOKE was put in mind of making experiments with the great loadstone formerly sent by Dr. COTTON.

London Fog.

Mr. HOOKE observed, that the air had been for a good while so thick about London, that he had not been able to see the new star *in collo Ceti*; and the other *in cingulo Andromedae*.

1667

Mussels.

Mar. 28. Mr. HOOKE presented some mussels grown in a stone at the bottom of the sea, for the repository.

Circular Pendulum.

Mr. HOOKE's demonstration of the curve line in the circular pendulum was referred to the next meeting.

Growth of Lettuce Seed.

The operator was ordered to try the growth of lettuce seed in open, exhausted, close, and compressed air, as it was suggested partly by Mr. BOYLE and partly by Dr. GODDARD; and likewise to try in an exhausted receiver, whether frog's spawn being enclosed there, the water, in which it is found, would come to any motion; this experiment being suggested by Mr. BOYLE.

Some of the members were of opinion, that by forcing out the air, the texture of the spawn would be extremely altered and spoilt.

Brick-making.

Mr. HOOKE proposed an expeditious way of making bricks, the consideration of which was referred to the next meeting.

Telescope.

He promised to bring a six-foot glass to compare with the reflecting box, to change the object glasses.

Brick-making.

Apr. 4. It was ordered, that Mr. HOOKE produce his method of making bricks with less charge and more speed than hath been hitherto used; as also, that he bring in his demonstration of the curve line regulating the circular pendulum, so as to make it move equally with unequal weights.

Transfusion of Blood.

It was likewise ordered, that at the next meeting an experiment be made of letting out the blood of a dog, both by a vein and artery, at one and the same time, out of vessels equally distant from the heart, as out of the jugular vein and a jugular artery; and that the operator provide a dog for that purpose.

That another such experiment be made, as Dr. KING had given at this meeting an account of; and that the recipient sheep be turned to graze again.

April 8.

(15) *Directions for Observations and Experiments to be made by Masters of Ships, Pilots and other fit Persons in their Sea-Voyages: Printed with Enlargements and Explications of what was formerly*

publisht of this Kind, suggested partly by Sir R. Moray, partly by Mr. Hook.

Phil. Trans., No. 24, pp. 433–48, April 8, 1667.

The Particulars:

1. *To observe the Declinations and Variations of the Compass or Needle from the Meridian exactly in as many places as they can and in the same places every several Voyage.*
2. *To carry Dipping-Needles with them.* Figure 1 represents a Dip Circle.
3. *To mark carefully the Flowing and Ebbing of the sea in as many places as may be.*
4. *To remark curiously the Scituation, Figures etc. of all dangerous Rocks, etc.*
5. *To sound the deepest Seas without a Line, by the help of an Instrument,* represented by Figures 2–5.[1]
6. *To keep a Register of all changes of Wind and Weather etc.* Fig. 6.[1]
7. *To observe and record all Extraordinary Meteors, Lightnings, Thunders, Ignes fatuos Comets, etc.*
8. *To carry with them good Scales and Glass-Viols of a pint or so with very narrow mouths which are to be fill'd with Sea-water in different degrees of Latitude, etc.*
9. *To fetch up Water from any Depth of the Sea.* Fig. 8.[1]

April 8.

(16) "*More Wayes for the same Purpose,* [*of R. Townley's Invention of dividing a foot into many thousand parts*], *intimated by Mr. Hook.*"

Phil. Trans., No. 25, p. 459, April 8, 1667.

[1] Hooke's original drawings for these figures are still extant.

Memoranda.

Apr. 11. Mr. HOOKE was put in mind to bring in a model for his expeditious way of making bricks; as also a six-foot glass to compare with his reflecting box by changing the object glasses.

Anatomical Drawings.

Apr. 18. The operator was ordered to carry some lobsters, flounders, or frogs [to Sir G. ENT's house]; and Mr. HOOKE was desired to be there, to make sketches of what should be observed.

Brick-making.

Mr. HOOKE produced his model for brick-making, and promised to produce another at the next meeting.

Circular Pendulum.

He was put in mind to bring in his demonstration for the curve line to regulate the circular pendulum; as also to produce his method of making spherical glasses bear great apertures without colours.

Level.

Apr. 25. Mr. HOOKE produced a level, almost the same with that of the French, of which an account had been lately published in the *Journal des Scavans*. He was ordered to give a scheme and description of it in writing.

Circumference of Earth.

He proposed a way of measuring the circumference of the earth with a twelve-foot glass and three stakes, to be practised in St. James's Park on a calm day. It was ordered to be put in execution as soon as might be.

Magnetic Needles.

Mr. HOOKE produced a letter to him from Mr. JOHN SELLERS dated at Wapping, April 12, 1667, and containing an answer to two magnetical queries printed in the *Philosophical Transactions*, No. 23, pp. 423, 424. Which letter was ordered to be entered into the letter-book.

Mr. HOOKE was desired to inquire of Mr. SELLERS, what method he used to make a needle turn north and south without touching it with a loadstone.

He remarked, that a drill, by making a hole with it in a piece of steel in a perpendicular position, would contract the verticity of north and south.

Mr. HOOKE was desired to cause to be made both horizontal

and inclinatory magnetic needles, as exact as might be, and to have an inclinatory one hung up constantly.

History of Matters Done by the Royal Society.

Apr. 29. Dr. WILKINS was desired to be mindful of selecting upon every head of the matters hitherto done by the society one or two instances to be offered to the council for their approbation, and then to be inserted in the *History*.[1]

It was ordered, that Mr. HOOKE bring to Dr. WILKINS the several heads, which he had drawn up for that purpose.

Circumference of the Earth.

May 2. Mr. HOOKE having proposed the experiment of measuring the circumference of the earth for the Monday morning following in St. James's Park at the canal; it was ordered, that the apparatus for it, viz. a telescope of 12 or 15 feet and some stakes, should be made ready against that time.

Brick-making.

May 9. The brick engine was produced again, and tried with some clay; but that being too stiff, the trial succeeded not.

The members discoursing afterwards upon the whole, and considering, that this way would require vast spaces of ground to lay the bricks upon thus made, thought best to lay it aside.

Menjot's Medical Book.

Mr. HOOKE was ordered to send to Sir GEORGE ENT's house the medical book lately presented by Monsieur MENJOT, a Parisian physician, in order that Sir GEORGE might peruse it and give an account of its contents.

Dipping Needles, &c.

He was likewise ordered to procure some both dipping and horizontal needles as exact as could be got; as also to make the apparatus ready for observing the variation of the needle.

Experiments Appointed.

The experiments appointed for the next day were:

1. To make trials with the great loadstone formerly mentioned by Dr. COTTON.

2. To try in St. James's Park between that and the following meeting, if it might be, the experiment of measuring the earth, and to give an account of the success at the next meeting.

Contracted Telescope.

May 16. Mr. HOOKE produced the two glass tubes, a common

[1] Sprat, *History of the Royal Society*, 1667.

one of six feet, and another of the new way by reflection. Being compared by exchanging the glasses, the members judged the common one to show the object more clear than the other did, though both showed it of near the same bigness.

Upon consideration it was found and declared by Mr. HOOKE, that the reflecting box had several defects: 1. That the intermediate glass of it was too thick. 2. That the glasses were not ground smooth. 3. That one of the glasses was convex, the other concave. It was ordered, that these defects be remedied against the next meeting.

Great Loadstone.

The great loadstone of sixty pounds weight was tried, both the pieces of it being tied together. It moved a needle at about seven feet and a half distance; the great piece at about seven feet distance; the little piece at near six feet.

It was ordered, that it should be tried again by Mr. HOOKE in private, and an account of what he had observed be brought in; as also that it should be tried how far a good magnet moves iron.

Mr. BOYLE moved, that it might be tried somewhere in the ruins of London, what was the declination of the needle after the fire; since it was affirmed by authors, that after the burning of Vesuvius, the declination was altered in those parts. It was ordered, that Mr. HOOKE should take care to have this done.

Barometer Readings During the Fire.

It being inquired how the quicksilver stood about and during the time of the fire, Mr. HOOKE affirmed, that he had found it very high. Mr. BOYLE had not found his tube so.

Mr. COLWALL promised, that he would bring in an account of the observations made by himself, of the several stations of the quicksilver for seven months together, and of its station at the time of the fire and after it.

Magnetic Variation.

It was again ordered, that the magnetic apparatus should be made ready to observe the variation of the needle at Whitehall.

Frictionless Needle.

Mr. HOOKE observed, that he had a way of handling the needle so, as that it should move without friction.

May 23. The experiments appointed for this meeting were called for, but none of them being ready, order was given not to fail of having them ready against the next meeting.

Respiration.

Mr. HOOKE moved, that some experiments might be made, to find whether it be the supply of fresh air, or the motion of the lungs, that keeps animals alive; which he said might be done by cutting a hole in the thorax, and making an incision in the lungs, and blowing into them by the *aspera arteria.* It was ordered, that the experiment should be made as soon as it could conveniently be done.

Vivisection.

He moved likewise, that the *intestinum rectum* in some animal or other might be cut off; which he thought could be as easily done as the taking out of a spleen; which experiment was also ordered to be made.

The operator was strictly charged to provide dogs from time to time for the use of the society, and of those, who, at the desire of the society, had undertaken to make experiments of several kinds upon them.

Experiments Appointed.

The experiments appointed for the entertainment of the DUCHESS OF NEWCASTLE were: 1. Those of colours. 2. The mixing of cold liquors, which upon their infusion grew hot. 3. The swimming of bodies in the midst of water. 4. The dissolving of meat in the oil of vitriol. 5. The weighing of air in a receiver, by means of the rarefying engine. 6. The marbles exactly flattened. 7. Some magnetical experiments, and in particular that of a terrella driving away the steel-dust at its poles. 8. A good microscope. These experiments Mr. BOYLE and Mr. HOOKE were desired to provide and take care of.

Magnetic Variation.

May 30. Mr. HOOKE was put in mind of making ready the magnetical apparatus for observing the present variation of the needle at Whitehall; as also to observe that variation in the midst of the ruins of London, according to the suggestion of Mr. BOYLE on the 16th of May.

Parasitic Worms in Cormorants.

A letter from Dr. POPE to Mr. HOOKE dated at Exeter, May 25, 1667, was read, giving an account of worms in the stomachs of cormorants, which he supposed to be the cause of their voracity. It was ordered, that it be filed up, and that Dr. POPE be desired to inquire, whether those cormorants had worms in their stomachs at all seasons of the year.

Circumference of Earth.

After the Duchess was withdrawn, Mr. Hooke was put in mind of the experiment of measuring the earth in St. James's Park, to be tried there on the Monday morning following.

Curators Proposed.

June 3. It was moved, that a fit person for another Curator to the society might be thought upon; and the council was desired accordingly to take it into consideration.

Mention was made by some of Dr. Walter Needham, by others of Dr. Richard Lower. This matter was left to further consideration.

Sour Ale.

June 6. A letter of Dr. Pope to Mr. Hooke concerning the way of making groat ale was read, and ordered to be filed up.

The sourness of this liquor gave occasion to speak of the causes of sourness in general, and the ways of curing liquors of it.

It was ordered, that the experiment should be made at the next meeting of dulcifying vinegar with red lead, oculi cancrorum, oyster-shells, crab's claws, chalk, &c. And that Mr. Hooke take care of this experiment.

Fall of Barometer Before a Storm.

Mr. Hooke remarked, that six or seven hours before the beginning of the storm of wind on the day preceding, the quicksilver in the wheel barometer had fallen very considerably, almost a quarter of a circle. Mr. Colwall confirmed this by the observations made by himself.

Circumference of Earth.

Mr. Hooke was ordered to prosecute the experiment of measuring the earth in St. James's Park. He named the Monday following for it. Mr. Neile was desired to speak to Sir Paul Neile in the name of the society, that he would obtain leave to make that experiment in the park.

Contracted Telescope.

Mr. Hooke was put in mind to perfect his reflecting box against the following meeting.

He intimated, that this sort of telescopes would serve for a very convenient helioscope, to look upon the sun at all times, when it shines, without offence to the eye.

June 12. Earthquake.

Magnetic Experiments.

June 20. Mr. BALLE was desired to make the magnetic experiment formerly discoursed of by Mr. HOOKE.

He acquainted the society, that Dr. COTTON had, according to his promise, sent to them a loadstone of about 160 pounds weight for a terrella, which he had chosen out of above twenty hundredweight of the same stone; and that it would move a needle at above six feet diameter.

Respiration.

The method of making the experiment of opening the thorax of a dog, and preserving his life for some time by blowing into his lungs with a pair of bellows, being discoursed of, Mr. HOOKE reported a former experiment of his, that he had taken away all the ribs and the diaphragm, and left only the spine and great vessels; and that the experiment had succeeded, so as the dog lived some hours by blowing into his lungs with bellows; but as he ceased to move the lungs, the dog presently fainted, but revived upon a fresh agitation of the lungs. It was ordered, that Dr. KING be desired to join with Mr. HOOKE to make this experiment before the society at the following meeting.

Mr. HOOKE acquainted the society, that a friend of his had made many experiments of respiration, which he was desired to give them an account of at their next meeting.

Reduction of Sharpness of Vinegar.

Mr. HOOKE tried the experiment, with which he had been charged at the meeting of June 6, of taking away the sharpness of vinegar, and reducing it to a real sweetness, by putting into a little quantity of vinegar some red lead in powder. The event was, that the sharpness of the vinegar was much abated, but not wholly discharged.

June 27. Mr. HOOKE made some experiments to dulcify vinegar, by infusing the filings of lead, egg-shells, brass, steel-dust, and oyster-shells, in several vials with vinegar; all which greatly deprived the vinegar of its acidity, and reduced it to some kind of vinosity. It was ordered, that these experiments be further prosecuted against the next meeting.

Earthquakes.

Mr. HOOKE reported, that he had observed cliffs of stone for near four miles together; that the natural position was horizontal, though in some places he had found them to lie much sloping, and in others perpendicular; which, he thought, might fall into those odd positions by some great earthquakes; and he was of opinion, that the great hills and mountains have been raised by earthquakes.

He mentioned a cliff in the Isle of Wight, the bottom of which was washed by the sea, wherein at a pretty depth below the top, and at many fathoms above the surface of the sea, he had found shells of several sorts; which he thought might possibly have been placed there by earthquakes removing the superficial parts of the earth raising the bottom of the sea, and sinking the surface of the land.

The Bishop of EXETER suggested, that those shells might be carried in by subterraneous canals.

THE ROYAL SOCIETY'S TERRELLA.

(*From Early Science in Oxford*, vol. i, p. 308.)

Upon this discourse of earthquakes some of the members were of opinion, that the great lakes might also be made thereby.

Mr. HOOKE related out of VARENIUS's geography, that in China, a lake of thirty leagues over was made by an earthquake, the earth then sinking; and in another place, for the space of forty leagues, the earth shook all at the same time.

Sir THEODORE DE VAUX mentioned, that a hill in Switzerland had been removed by an earthquake, with the vines and some trees still growing upon it.

Cotton's Loadstone.

Mr. BALLE was desired to send the loadstone, lately presented by Dr. COTTON, to Mr. HOOKE, who was to take care to have it well wrought into a terrella.

Heart-beat in an Embryo.

Mr. HOOKE reported, that he had taken a whelp out of the

uterus, and dissected it in the evening, and that the heart beat the next morning, when he came to look on it again.

Respiration and Combustion.

Mr. BOYLE related, that he knew a man, who by a way used by him would undertake to be three hours at a time under water without any prejudice.

This gave occasion to discourse, what quality it was, that made the air fit for respiration. Some thought it became unfit by being clogged and entangled with gross vapours. Mr. HOOKE was of opinion, that there is a kind of nitrous quality in the air, which makes the refreshment necessary to life, which being spent or entangled, the air becomes unfit.

He related an experiment long since made before the society with a chafing-dish of coals set in a close box, wherein was a pair of bellows so contrived, as to blow the coals with that air only, that was included in the box: the air so kept had this quality, that after one whole day's time fresh fire would not burn in it, till the grosser parts thereof were precipitated.

Large Rarefying Engine.

It was proposed by Mr. HOOKE to have a rarefying engine made of wood big enough for a man to sit in. This was approved of by Mr. BOYLE. Mr. HOOKE thought, that such an engine might be made for five pounds; and was ordered to have one made as soon as possible.

Submarine.

He proposed a contrivance, which he had, to make a vessel to swim in under water, of any dimension, wherein he might pass as fast as in a wherry upon the Thames, and at any depth he pleased with safety. He was ordered to compute the charge of such an engine, and report it to the society at the next meeting.

Minerals from Loadstone Mines.

Mr. BALLE produced some spars and diamonds of several kinds, asbestos, and some other stones of a murrey colour, taken out of the loadstone mines; which were delivered to Mr. HOOKE for the repository.

Respiration Experiment.

July 4. The experiment of opening the thorax of a dog, ordered at the preceding meeting, being again called for, was deferred till the following one on account of the absence of Dr. KING. Mr. HOOKE was desired to join with any physicians of the society, and to take care, that the experiment be then made without fail.

Dulcification of Vinegar.

Some other experiments about dulcifying vinegar by dissolving therein crustaceous substances and metals, ordered also at the preceding meeting, were not made at this.

Instrument to Produce Air out of Water.

Mr. Hooke excused the want of experiments at this meeting, in regard he had spent great part of his time in examining an instrument, whereby to produce air out of water, which did not succeed; on which account he was of opinion, that little air is made out of water, but what may rush into the pipes together with it, as in the bellows at Tivoli. Mr. Hooke was ordered to bring in a description of this instrument, and an account of the experiments in writing, at the next meeting.

Convexity of Canal in St. James's Park.

Mr. Hooke and Mr. Balle were desired to observe the convexity of the canal in St. James's Park, and to give an account of it to the society at their next meeting.

Respiration Experiment.

July 11. Mr. Hooke desiring to be excused from making the experiment of opening the thorax of a dog, Dr. Balle and Dr. King were requested to take care of it at the next meeting.

Mr. Hooke having made this experiment formerly was desired to give some account of it; who related, that he had cut away all the ribs of the dog, taking out the diaphragm, and left only the spine and the great vessels; and that blowing with a pair of bellows and a pipe thrust into the windpipe of the dog, the heart continued beating, and the eyes very lively for the space of two hours, which might have lasted much longer; but upon ceasing to use the bellows, the heart grew convulsive and dying, which likewise would recover again as soon as the motion was renewed. He remarked, that he designed this experiment to understand the nature of respiration.

Barometric Record.

Mr. Mercator's observations of the barometer from the 6th of December to the 7th of July were brought in by Mr. Hooke, and ordered to be entered.

Micrometer.

Mr. Hooke reported, that Dr. Croune had received from Richard Townley, Esq., Mr. Gascoyne's instrument for measuring the diameter of the stars with great exactness; which instrument was afterwards showed to the society, with the models of some others; and the improvement of the first invention.

Mr. HOOKE mentioned, that he had invented an instrument of this kind, but upon another principle, which would perform the same things better, with more certainty and more ease.

Planetary Theory.

He related also, that he had a theory, which would solve all the unequal motions of the planets; which he was desired to show the society at their next meeting.

Large Rarefying Engine.

He brought in the rarefying engine, fitted with a wooden vessel, large enough for a man to sit in, which was tried; but not being sufficiently tight, it was ordered to be fitted against the next meeting, and to be then tried.

Micrometer.

July 25. Mr. HOOKE brought in Mr. TOWNLEY's instrument for measuring diameters to very minute parts, consisting of a screw with indexes, &c. He reported, that Dr. CROONE had a description and scheme of the instrument from Mr. TOWNLEY himself, which was ordered to be brought in and entered in the register; as also, that the operator should make one of the same kind to be kept in the repository.

Mr. HOOKE produced likewise an instrument of his own invention for the same purpose, but of more plain and easy use, it consisting of two threads and a ruler, whereby an inch is diagonally divided into five thousand parts, and might be with the same ease divided into forty thousand or more at pleasure; to which was to be fitted part of a tube, whose circle is divided into 360 degrees, and a thread passing through the diameter, which would serve to find the true position of any star, &c.

It was ordered, that Mr. HOOKE bring in an account of his instrument in writing, with a scheme of it, to be entered into the register book; and that one of the same kind be likewise made to be kept in the repository.

Mr. HOOKE mentioned, that he had another invention of an instrument to measure diameters with great exactness, which he promised to give an account of at the next meeting.

Large Rarefying Engine.

Report being made, that the great box fitted to the exhausting engine had not succeeded according to expectation, the air (as Mr. HOOKE supposed) getting in at the brass sucker, he informed the society, that he had since fitted it with a wooden sucker instead of that; which would be ready against the next meeting.

Dr. WILKINS related, that by some experiments of this kind,

which he had made long since at Oxford, it was found, that the air compressed in an engine would work through the pores of wood, though an inch thick; which he discovered by throwing water on the wood, wherein would appear many bubbles caused by the expression of the air from within.

To prevent which in this box Dr. KING advised, that it might be covered with a good sear-cloth made so, that it might keep the vessel tight enough to prevent any recourse of air. But Mr. HOOKE replied, that he thought he had stopped all possible passages of air with cement, so that it would now perform very well; and if this should fail, he thought there was no better way than to have it covered with lead.

But it was objected by Mr. HENSHAW, that all sorts of sear-cloth will stretch, and the pores be opened by that subtle force. He inquired likewise, whether it were fresh air or vapours, that came in upon exhausting the box? and was answered by Mr. HOOKE, that at those times, when he sat in the box to make the experiment, all the difference, which he found, was only a little extraordinary heat.

Mr. HOOKE moved, that since the cement about the engine was very subject to crack in the carriage from Gresham College to Arundel House, whereby it became defective, a committee might be appointed to see some experiments made with it at his lodgings in that college, and to report the same to the society.

Loadstone Mines.

Mr. HOOKE moved to have a description of the place, where the Exeter loadstones were found, and to know how the poles lay in the earth, whether parallel to the axis, or after the manner of the dipping-needle, or parallel to any meridian; which might be known by taking the position of any stone there.

Mr. HOOKE was of opinion, that metals and those mines were at first thrown up by earthquakes, though there are metalline waters, that crystallize, as is seen in the various figures in antimony and other metals; but that gold is made by an extraordinary subterraneous heat, because it is always found in metal, not in ore. To which it was answered, that there is gold to be found in all metals.

Convexity of Canal in St. James's Park.

Mr. HOOKE and Mr. BALLE were earnestly desired to make the experiment of observing the convexity of the canal in St. James's Park, and not to fail of giving the society an account of it at their next meeting; and Mr. NEILE was desired to procure leave from the Duke of ALBEMARLE under his hand.

Sept. 5.

LETTER FROM HOOKE TO BOYLE.

Gresham College, Sept. 5, 1667.

Honourable Sir,

We have had so little worth communicating since your departure, that I have hitherto forborn to give you the trouble of a letter; and the business indeed of this paper is nothing but to express my service and duty. For most of the Society being out of town, we have for some weeks omitted our meetings, and so there has been nothing done at *Arundel* house. And the heat of the weather, till of late, has been such, that I could not proceed with the experiment of the airbox, though, upon my next attempting of it, I despair not of bringing it to a good issue, which the coldness of the weather, and the meeting of several of the Society every Thursday in the afternoon at my chamber, will now speedily put me upon. There will be, I doubt not, very many noble experiments discovered by it, of which I have conceived a good number. And I hope likewise to add one contrivance more to this enquiry, and that is, to be able to do the same things in the open air, which can be done in the box, without any danger to him, that shall ascend into the air; which contrivance, if I can perfect, will be of great use upon many other accounts. I was lately informed of a very pretty experiment of reducing the whey and curds of a posset back again into milk, by the nature of a certain liquor. I doubt not at all of the truth of the experiment; but I do not yet certainly know the liquor, with which it is done. I question not, but that you will easily find many, that will do it; I have not, I confess, myself had any time to make enquiry after it since. I have, upon some trials, found a liquor, that does brighten steel, and extract a blood-red tincture from it, which has neither the ill taste nor smell of other solutions of that metal. I believe the tincture may be of good use in physick, as well as the brightning of steel will be to mechanicks. I suppose you have heard before this from Mr. OLDENBURG, who is got out of limbo, and now again breaths and enjoys the free air. He will not, I hope, leave off his philosophical intelligence. I hope this peace will reduce all things again into order, and be a means likewise of hastening your return to *London*, where you are very

much expected and wished for. I hope I shall prevail upon Dr. Lower, and for him, so as to get him anatomical curator to the Society. He has most incomparable discoveries by him on that subject, and a most dexterous hand in dissecting. Some of his discoveries I understand will be published in the next edition of Dr. Willis's book *De Cerebro*. Political news I doubt not but you understand from better intelligence. I am,

Honoured Sir,

your most faithful

humble servant,

Rob. Hooke.

There were about half a score of the Society met at my chamber this afternoon, where we had some discourse of philosophical matters, to keep the memory of that subject alive. I have lately contrived a new way of wheel work for clocks, watches, &c. which I think does much excel all the ways yet known: and indeed I think it the very perfection of wheel work, and capable of the highest perfection, that can be expected in that kind. There has been nothing like it yet practised. Many other things I long to be at, but I do extremely want time.

Caretaker.

Sept. 30. It being then mentioned, that a gardener at Little Chelsea, a married man, was willing to live in the college, and to take care of the society's concerns there, and was likely to be content with a very reasonable allowance; it was ordered, that he should be spoken with by Mr. Hooke, who knew him.

Micrometers.

Oct. 3. Dr. Croone moved, that Mr. Gascoyne's instrument, sent by Mr. Townley, and produced at a former meeting before the society, for the dividing of an inch into many thousand parts, might be taken into further consideration; and that himself might be directed, what answer to return to Mr. Townley concerning it. Upon which it was ordered, that the instrument should be produced again at the next meeting.

And Mr. Hooke mentioning, that he had contrived an instrument for the same purpose, and performing it with more conveniency, and to be made with more ease and for less charge, he was desired to produce that contrivance at the next meeting; which he promised to do.

Cider Engine.

Mr. PACKER moved, that an engine might be considered more convenient and proper to make cider, than that which is now employed for that purpose; and mentioning, that he understood, that Mr. HOOKE had thought upon such a one, capable by one motion to break the apples, to put aside the husks, and to cause the liquor to run out, the society desired Mr. HOOKE, that, if he had such a contrivance, he would bring in a model of it as soon as he could: which he promised to do.

Respiration.

The experiment appointed to be made at the next meeting by Mr. HOOKE was the opening of the thorax of a dog, to blow with bellows into his lungs, and thereby to keep him alive: which experiment might conduce to the discovery of the nature and use of respiration. The operator was ordered to provide a dog for this purpose.

Large Rarefying Engine.

Mr. HOOKE was likewise ordered to prosecute the experiments in the rarefying engine capable of holding a man; as also to endeavour to make the experiment for measuring the compass of the earth, moved so long ago, and pressed so often, to be performed in St. James's Park.

Respiration Experiment.

Oct. 10. The experiment of opening the thorax of a dog was made by Dr. LOWER and Mr. HOOKE, which succeeded well, as it had done formerly, according to the account already registered of it. Sir GEORGE ENT reflecting upon this experiment, said, that it showed what was not the use of respiration, but not what it was: that the lungs not beating at all, but only kept extended with fresh air blown in by bellows, showed, that the lungs did not serve to promote by their agitation the motion of the blood. Mr. HOOKE considered, that the dog being continually supplied with fresh air was kept alive, but was ready to die, if either he was left unsupplied, or his lungs only kept full with the same air; and thence conceived, that the true use of respiration was to discharge the fumes of the blood.

Micrometer.

Mr. HOOKE produced likewise his instrument for the same purpose, but made with far less charge, and performing the same thing with more ease. He was ordered to have such a one made for the society, and to bring in a description of it, and its use.

Sugar Works.

The papers of Sir THEODORE DE VAUX were delivered to Mr. HAAK and Mr. HOOKE to peruse them, and to consider of what use they might be for the history of sugar works.

Soap-making.

DE VAUX gave in likewise a paper concerning the way of making both soft and hard soap; which was recommended to the perusal of those members, who had undertaken to bring in the history of soap-making; and of whom Mr. HOOKE was one.

Histories of Trades.

It was desired likewise, that those persons, who had formerly engaged in the bringing in of the histories of trade, would be mindful of their engagements; as particularly Mr. HOOKE of soap-boiling and hat-making; Mr. HOOKE and Mr. THOMAS COXE of sugar-refining, &c.

Respiration.

Oct. 17. The experiment made at the former meeting, of preserving a dog alive by blowing into his lungs with bellows, and keeping the lungs extended by a constant supply of fresh air, being again considered of, it was observed by Mr. HOOKE, that this experiment seemed to show, that an animal might be kept alive without any motion of the lungs, only by a continued supply of fresh air; and that the motion of the lungs did not contribute to the circulation of the blood. He was desired to bring in an exact description of this experiment, as it was now improved.

Soap-making.

The paper about soap-making given in by Sir THEODORE DE VAUX was delivered to Mr. HOOKE, who undertook to give an account of that trade.

Circulation Experiment.

The experiment appointed for the next meeting, upon the suggestion of Mr. HOOKE, was that of making the blood of an animal pass from one side to the other out of the vena arteriosa into the aorta, without passing through the lungs. Dr. LOWER and Mr. HOOKE were desired to take care of this experiment.

Magnetic attraction.

Oct. 24. A magnetical experiment was made seeming to show, that the poles of the magnet attract as well as direct: and it was ordered to be repeated at the next meeting in a larger box closed

with glass; and an account of it was directed to be brought in by Mr. HOOKE.

Respiration.

Mr. HOOKE's account of the experiment of keeping a dog alive by blowing into his lungs, and even without the motion of his lungs, only by keeping them extended with a constant supply of fresh air, was read, and ordered to be registered.[1]

Transfusion of Blood.

Mr. HOOKE and others were desired to speak with Dr. ALLEN, physician to Bethlem, about the execution of this trial of the method of transfusing blood into a man, as it was contrived by Dr. KING, and to let him know the opinion declared in the society concerning it; which they undertook to do.

October 24.

(17) *An account of an experiment made by Mr. Hook of preserving Animals alive by blowing through their Lungs with Bellows.*

Phil. Trans., No. 28, pp. 539–40, October 24, 1667.

'This noble experiment came not to the Publisher's hands, till all the preceding particulars were already sent to the Press.—24 Oct. 1667.'

A Perfect Wheel-work and a Micrometer.

Oct. 31. Mr. HOOKE produced two instruments of his own contrivance; one called by him a perfect wheel-work, so made as equally to communicate the strength of the first wheel to the last, the teeth of it being always taking, so as before one tooth had done taking, it was passed a good way into another. The other was an instrument for observing the diameters, positions, and angles of the stars, conceived to be more plain, easy, and less chargeable than that of Mr. TOWNLEY. He was desired to bring in an account of both in writing, and to take care, that Mr. TOWNLEY, who had before communicated to the society an instrument for the like purpose, might be made acquainted with this new contrivance.

Magnetic Experiment Fails.

The magnetical experiment, which was tried at the last meeting with a seeming success, was tried again at this, but did not succeed at all. Mr. HOOKE was desired to give an account of this in

[1] Cf. R. S. MS. No. 45.

writing, the unsuccessful experiments being as well to be registered, as those that succeeded.

Salt-making.

Mr. COLLINS moved, that some queries might be drawn up concerning [the making of salt in Cheshire], which he would recommend to the person, who had given the account, and whom he thought very well able to answer whatever should be inquired of upon that subject. Mr. HOOKE was desired to draw up such queries.

Transfusion of Blood.

A report being made of Dr. ALLEN'S scrupling to try the experiment of transfusion upon any of the mad people in Bethlem Hospital, it was ordered, that he should be desired by Mr. HOOKE to give a meeting at Sir GEORGE ENT'S house on the Monday following to some of the physicians of the society, as Sir THEODORE DE VAUX, Dr. CLARKE, Dr. LOWER, Dr. BALLE, and Dr. KING, to consider together, how this experiment might be most conveniently and safely tried.

Anatomical Curator.

Nov. 5. It being represented to the council, that it was very necessary to have another curator, and Dr. LOWER being proposed as a person very fit to be a curator in anatomical experiments,[1] Dr. WILKINS was desired to speak with him about it.

Boy assistant.

It being moved, that a boy might be allowed to Mr. HOOKE, fit to be employed by him on such occasions, as concerned the service of the society, it was agreed upon by the council, that Mr. HOOKE should find out such a boy, and that fifteen pounds a year should be allowed him towards the keeping of him.

Circulation Experiment.

Nov. 7. Mr. HOOKE speaking again of his experiment of passing the blood of an animal out of one side to the other without its passing through the lungs, and showing his contrivance for performing it, was ordered to try it first in private; and lest there should fall too much air upon the blood, moving openly into the porringer

[1] Mr. HOOKE in a letter to Mr. BOYLE dated at Gresham College, Sept. 5, 1667, and printed in Mr. BOYLE'S Works, vol. v, p. 548, says: 'I hope I shall prevail upon Dr. LOWER, and for him, so as to get him anatomical curator to the society. He has most incomparable discoveries by him on that subject, and a most dextrous hand in dissecting. Some of his discoveries, I understand, will be published in the next edition of Dr. WILLIS'S book *de Cerebro.*' *See* pp. 313–4.

from one side to the other, it was suggested, that a kind of cover should be prepared for the porringer to regulate the quantity of the air.

Micrometer.

It being moved, that the scheme and description of Mr. TOWNLEY'S astronomical instrument should be brought in by Mr. HOOKE, and entered, answer was made, that both were ready and in the hands of the Secretary, who promised to produce it at the next meeting.

Cider Engine.

Mr. HOOKE being called upon for the scheme or model of the new instrument for making cider, and not having it ready, was desired to produce it at the next meeting.

November 11.

(18) *A Description of [Mr. Townley's] Instrument for dividing a Foot into many thousand parts, and thereby measuring the Diameters of Planets to a great exactness etc., as it was promised No. 25.*

Phil. Trans., No. 29, p. 542.

'. . . For the draught of the Figures representing the New Instrument itself and the description of the same, we are obliged to the ingenuity of Mr. Hook' (publisher's note). [With 5 figures.]

Cometographia, Long Telescopes and Telescopic Sights.

Nov. 14. Mr. HEVELIUS gave notice of his *Cometographia* being almost finished; and expressed his desires, both of having one of the longest telescopes, made in England, provided for him, and of being gratified with a full description, formerly promised him by Mr. HOOKE, of the way of applying telescopical sights to sextants, thereby the better to regulate and assist the sight in the mensuration of the distances of stars. Which requests of his the society thought should be complied with as far as possible; and particularly desired Mr. HOOKE to be mindful of his promise concerning those sights.

Circulation Experiment.

Mr. HOOKE related, that his experiment of making the blood of a dog pass from one side to the other, without passing through the lungs, had not succeeded in the way hitherto contrived by him; but that he had thought of another method, which he would further consider of.

He was desired to give in writing all the particulars of the operation, and what hindered the success.

Micrometer.

Mr. HOOKE's description of an instrument contrived by Mr. TOWNLEY for dividing a foot into many thousand parts, and thereby measuring the diameters of planets with great exactness, was read and ordered to be registered.

It was ordered, that one of the astronomical instruments for dividing a foot into many thousand parts, as it was contrived by Mr. HOOKE, should be made for Mr. HEVELIUS, at the charge of the society, and sent to him, as from them, by Mr. OLDENBURG.

Eclipse of Moon.

Mention being made, that on the 20th of the present month of November there would be an horizontal eclipse of the moon, it was ordered, that Mr. BALLE and Mr. HOOKE should make observations accordingly.

Auditor.

Nov. 21. Mr. HOOKE nominated auditor.

Eclipse not observed.

Mr. BALLE and Mr. HOOKE being called upon for their observations of the horizontal eclipse of the day before, they said, that they could not observe anything, the weather not being favourable.

Circulation Experiment.

Nov. 28. Mr. HOOKE being called upon for an account of the experiment which he undertook to try in private, of passing the blood of a dog from one side to the other without its passing through the lungs, said, that he had attempted it, but that it did not succeed so well as he wished; but that he thought he had now devised a method of making it succeed as he desired, of which he hoped to give the society a good account at the next meeting.

Reduction of an Equation.

Mr. HOOKE was given a copy of a letter from R. F. SLUSIUS giving an account of his method of reducing an equation of the fourth degree by a circle and a parabola.

Experiments on Light.

Dec. 5. Mr. OLDENBURG brought in the sequel of Mr. BOYLE's experiments about light, several of which were read, and the rest referred to the next meeting.

Mr. HOOKE was put in mind of preparing for the experiments

of this kind to be made as soon as might be, according to the particulars appointed at the meeting of November 28.

Time Measurement.

Dec. 12. Mr. HOOKE being called upon for giving an account of what he thought of the method of measuring time, brought in at the last meeting by Mr. AUBREY and Mr. WYLDE, said, that though the inventions were ingenious, and, as he thought, new; yet that by reason of the inequality of the air, caused by the various degrees of its rarefaction and condensation, as also of its dryness and moisture, it would not be fit for pocket-watches, nor of that exactness and use, that pendulums were.

Slusius's Theorem.

Mr. HOOKE and Mr. COLLINS were put in mind of giving an account of Monsieur SLUSIUS's theorem, committed to them on the 28th of November, in order to be examined by them.

Circulation Experiment.

Mr. HOOKE was called upon for the experiment of circulating the blood of an animal out of the veins into the arteries through an open vessel, without passing through the lungs. He said, that he would prepare it as soon as he could.

Painting.

Dec. 19. It was ordered hereupon, that Mr. HOOKE and others should be desired to meet to consider of the particulars to be inquired into concerning the curiosities in the art of painting.

Respiration of Foetus.

Mr. HOOKE communicated an account of an experiment tried by him in the presence of Dr. LOWER upon a mastiff bitch big with puppies, to see, whether foetuses live in the womb by their own or the mother's respiration. It was ordered to be registered,[1] and was as follows:

In prosecution of the former inquiry about respiration, to know whether the life of the foetus in the womb were continued without its own respiration, by means of the ventilation of the blood of the dam by its respiration; upon Wednesday the 18th of December, 1667, Dr. POPE and myself tried the following experiment. We took a large mastiff bitch, that had gone about seven weeks with puppy, and binding her down on a table, we opened the right side of the belly about the middle, between the spine and the middle muscle of the belly, and through that perforation taking out one of the horns of the uterus, and opening

[1] Cf. R. S. MS. No. 46.

it, we took out one of the whelps, that was large and lusty, and seemed to be almost ready to be whelped. Then before he had taken in any breath, we opened the throat, and disclosed the aspera arteria, and running a needle and thread suddenly under it, we tied it so fast, that nothing of air could pass in or out by it; then wrapping up the foetus in warm linen cloths, we laid it by the fire, but it survived but some few minutes, and then died. Then we took out another, and, instead of taking it out of its enclosed skins, as we had done the former, we made a gentle ligature about the neck upon the amnion, including the head of the whelp, as it were in a bladder, of its own natural liquor, so as neither air, or any other liquor, but the liquor of the amnion could come to the mouth. Then we suffered it to lie in water warmed to about the same heat with the natural heat of the womb of the bitch; but neither did this long survive; but we took notice, that the whelp within a minute or thereabouts, after he had been separated from the dam, began to gape and strain as it were to take in breath, and after a little while died. We tried likewise a third, by keeping his head and mouth all the while till we had, according to the former method, tied up his aspera arteria; then keeping him warm in cotton wool warmed and laid by the fireside we found him moveless within some few minutes. A fourth we tried by suffering it to lie in its own bags and liquors without making any ligature at all, either by a band about its neck, or by a tying about the aspera arteria: this also we found as subject to fate as the rest, for he seemed to be dead as soon as any of the rest, though it was expected, that it would have lived a very long time. So that upon all these observations we found, that none of them would survive ten minutes of time measured by a pendulum-watch.

These experiments seem to hint, that the foetus in the womb has its blood ventilated by the help of the dam; and that it is not the want of the motion of the blood through the lungs, or the imaginary stopping of it there, that kills the foetus; since we have no reason to believe, that the foramen ovale was shut in these whelps, before they had taken in any air into their lungs. Nor can we imagine any other cause of the so sudden death of them, save only the want of the ventilation of the blood, or whatever other operation respiration may be proved to work on the blood: and methinks also it may seem very manifestly to prove the continual and necessary communication of the blood of the dam with that of the foetus, and of the immediate dependance of the one upon the other.

One thing by the way we took notice of, which was not to be passed by, and that was, that in one of the cells of the womb we found a foetus dead, which seemed to have lain so in that place

for above a month; which we guessed by its bigness, that was very small in comparison of the other, which we had taken out alive; which seemed to show a very great providence of nature, for the keeping of that dead foetus in the womb without at all prejudicing of it, until the time of the birth of all the rest.

A Method for making a History of the Weather. By Mr. Hooke.

Sprat, *History of the Royal Society*, 1667, pp. 173–9.

Plate of barometer, compass and wind-pressure gauge.

See page 270.

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Clockwork.

Jan. 2. Mr. Hooke produced a piece of clockwork, said to serve always to promote a pendulum straight, without any check at all. It not being yet complete, it was ordered to be produced again at the next meeting with the addition of what was necessary to perfect it.

Cider Engine.

He was put in mind of his new cider engine, and ordered to get a model of it made, as soon as conveniently he could.

Weather Forecasting.

He produced a paper giving an account of a way devised by him of discovering the various pressures of the air at sea, to predict the alteration of weather, and to foresee storms. It was ordered to be registered; and Mr. Hooke was desired to get such a weather-glass made, as was described in this paper, as soon as he could.[1]

Memoranda.

He was put in mind of making the experiments with shining wood and fish, both in the exhausting engine and in a close glass, with the same air always remaining: of circulating blood in an open pipe, without its passing through the lungs: of the experiments in the rarefying box, and that in the park, when the weather should serve; and of swelling the head of an old dog by tying up the external jugulars.

Mr. Hooke produced a Latin letter sent him from a Bohemian with a little book in the German tongue.

[1] Cf. R. S. MS. No. 48.

New Level.

Jan. 9. Mr. HOOKE was desired to make a draft of a new kind of level to be sent to Monsieur AUZOUT.

Micrometer.

It was ordered likewise, that Mr. HOOKE should bring in a description of his new astronomical instrument, answering to that of Mr. TOWNLEY for dividing a foot into many thousand parts, and thereby observing with great exactness the distances of the parts; and that the copy of it should be sent to Mr. HEVELIUS.

Design for College.

Jan. 11. Mr. HOOKE was desired to bring in at the next meeting of the council a draft for the building of the society's college.

Weather Glasses.

Jan. 16. Mr. HOOKE produced the two weather-glasses, one open, the other closed, for observing the various pressures of the air at sea, in order to predict alterations of weather. He was ordered to see another made very accurately, to be recommended to some careful seamen to carry it to sea, and to make observations therewith.

Cider Engine.

He produced a model of his new cider engine with the addition of a contrivance for cutting the apples. He was desired to consider of this, and to endeavour to add it to this contrivance.

Pendulums for Clocks.

Mr. HOOKE produced likewise his new contrivance of promoting the vibrations of pendulums, so as to prevent all checks, which he affirmed to have been provided against by no invention hitherto. He was desired by the Lord BERKLEY to take care of having such a one made for him, and by the society to bring in, as soon as he could, the descriptions and schemes of this instrument, as well as the other two produced before, viz. that of the sea weather-glasses, and the cider engine.

Magnetisation without increase of Weight.

Jan. 23. Mr. HOOKE made an experiment to discover, whether a piece of steel first counterpoised in exact scales, and then touched by a vigorous magnet, acquires thereby any sensible increase of weight. The event was, that it did not.

Substance heavier than Gold.

He proposed an experiment to discover, whether any substance

could be made heavier than gold. It was ordered, that the trial should be made before the society the next day.

He was ordered to take care, that the experiments concerning shining wood and fish be made at the next meeting, both in the compressing and rarefying engine.

Cider Engine. Pendulum Clock. Dividing Engine.

He was desired to bring in the description both of his new engine for grinding and pressing of cider fruit, and of his clock-work for promoting the vibration of a pendulum straight, without any check; as also of his instrument for dividing a foot into thousands of parts, for making exact astronomical observations.

Croone's Wind-gathering Vessel.

Feb. 6. Dr. CROONE produced his wind-gathering vessel, which was examined and thereupon ordered to be improved, according to the suggestions of Mr. HOOKE, and to be brought in again thus improved at the next meeting.

New Star. Balsora Earthquake.

Mr. HOOKE produced a letter written from Balsora, near the Persian Gulf, by Mr. HENRY POWELL, January 6, 1665/6, giving an account of a new star and dreadful earthquakes in those parts, which letter being read, was ordered to be entered in the letter-book.[1]

Penetration of Metals.

Feb. 13. Mr. HOOKE gave some account of the experiment, which had been proposed by him to be tried, of making a body heavier than gold, by putting quicksilver to it, to see, whether any of it would penetrate into the pores of gold. He related, that he had tried it, and found, by weighing the gold in water before and after the addition of mercury, that it had acquired somewhat a greater ponderosity; but that he did not rely on that experiment, and would therefore try it again more exactly.

It was moved, that this experiment might be extended further, viz. to try what metalline bodies penetrate into one another, in order thereby to make compound bodies to be heavier than the compounding parts are, weighed when asunder: This trial to be made with lead and mercury, with tin and copper.

Wind Detector.

Dr. CROONE produced again his vessel for rendering wind discernible, when it is not discerned by any sense without it.

[1] p. 136. It is printed in Mr. HOOKE's *Philosophical experiments and observations*, p. 29.

Mr. HOOKE exhibited another such vessel of another contrivance. It was ordered, that they should be both tried and compared, and an account of the effect given to the next meeting.

Brain affected by the Moon.

Mr. HOOKE related, that Sir WILLIAM STRODE had assured him, that he knew a man, who had a hole in his skull, through which it was seen, that his brain grew turgid at the full and flaccid at the new moon. He was desired to bring the account of this in writing from Sir WILLIAM STRODE.

Weight of Alloys.

Feb. 20. The experiment of weighing tin and copper was made, so as two pieces of those two metals were weighed, both asunder and mixed, in the air and water; whereby it appeared, that the compound was heavier than the parts separated. Mr. HOOKE was ordered to give an account of it in writing; as also to bring in the description of the new cider engine, the astronomical instrument, and the new pendulum moving straight without any check.

Arterial Experiment.

Feb. 27. Mr. HOOKE was desired to assist in the experiment of compressing the descending artery in a dog, to see, whether thereupon the motion of the animal would quite cease.

Cider Engine.

The new cider engine being again spoken of by Mr. PACKER, it was ordered, that Mr. HOOKE should take care of having one made of that kind, not exceeding forty shillings.

Hydrostatic Balance.

Mr. HOOKE produced a more exact contrivance of scales for the weighing of bodies both in the air and water. It was ordered, that these experiments should be prosecuted at the next meeting: and

Wind Detector.

That the vessel for contracting of the wind, with the alterations formerly appointed to be made, be produced at the same meeting.

Incubator.

Mar. 5. Mr. HOOKE moved, that some ways might be considered of, to practise the hatching of chickens in England, without any animal; and having suggested the lamp-furnace, and a certain sweet substance keeping heat for many days (which

he did not think fit to name then) he was desired to make the experiment in the best manner he could think of, and to give the society an account of its success.

Spherical Glasses.

The account of the performances of Mr. SMETHWICK's new optic-glasses being read, it was moved, that they might be tried once more, by comparing them with spherical glasses, before they passed abroad with the attestation of the society. This being approved of, Mr. HOOKE was desired to provide accordingly for the next meeting as good spherical glasses as he could procure, both for a telescope, reading and burning-glasses; which he undertook to do.

Wind Detector.

The wind-gathering vessel with some improvements was again exhibited, and appeared to be sensible of the least wind near it. It was ordered, that a description should be made of it, together with a scheme, and registered.

Otacousticon.

Mr. HOOKE suggested, that such a vessel as this might, by some variation, be turned into a good otacousticon: upon which he was desired to procure one to be prepared against the next meeting.

Lens Grinding.

Mar. 12. Mr. HOOKE made a proposal of a new way of his to grind optic-glasses, which he was desired to give in writing.

Wind Detector.

Mr. HOOKE brought in a description of the wind-gathering vessel, but took it home again, promising to return it at the next meeting.

Weight of Alloys.

The experiments of weighing bodies of two mixed metals, made heavier than the metals apart, both weighed together, should be prosecuted at the next meeting.

Experiments of the Academia del Cimento.

Mar. 19. Some account was given by Dr. POPE and Mr. HOOKE of the book of the experiments of the academy *del Cimento*, which was, that the many subjects and experiments treated of in it had also been considered and tried in England, and even improved beyond the contents of that book; but that they were delivered in it with much accuracy and politeness, and some of

them with an acknowledgement of the origin, whence they were derived.

Wind Detector and Otacousticon.

A description of an instrument for collecting the wind, or for making the slower motions of the air more sensible, contrived by Mr. HOOKE, was read, and ordered to be registered, as follows:

It was contrived by Dr. CROONE, to include a fan in a cylindrical vessel, and to divide the whole circumference thereof into thirty-two or more equal parts, and at those several divisions, to cut slender slits for the air to be admitted by those narrow passages into the cavity of the cylindrical box; as supposing the air moved affected to move swifter through any narrow crevice: but upon considering the matter, I found, that a contrivance of that kind did very much shroud and shelter the fan, placed in the centre of the cylindrical box, from being moved by the motion of the air, and not in the least conduce to the making it sensible. To remedy therefore this inconvenience, I contrived an instrument after such a manner, that the boxes and cells thereof should collect as great a quantity of air in motion, as could enter a square hole every way as big as the greatest diameter of the instrument, and contract it into as small a passage as was desired; by which means it is possible to make the slowest and most imperceptible motion of the air to be equal to the greatest and most swift.

The contrivance, in short, was this: I caused two hollow tin cones, *a, b, c, d, e,* and *a, f, g, h,* to be inverted and meet each other in the common vertex or point *a*: then dividing the limb of each into 32 equal parts, I caused to be cut so many triangular valves or partitions *a, b, f, a, t, u, a, p, q, a, i, k, a, e, g, a, l, m, a, n, o, a, r, g, a, d, h,* &c. as there were divisions, cutting off only an equal triangular bit at the top of them, or towards the centre *a,* as that they might leave a cylindrical hole in the centre of this instrument, fit to contain a small vane or weather-cock. These valves or partitions were soldered on between the two cones, in the manner expressed in the figure; by which means, all the air, that was moved against the side of the cylinder *f, b, e, d, h, g,* was collected to pass through the narrow small holes, making up the little square at *a,* and thereby consequently the motion of the air through the holes, or outlets, to the motion of the air through the greater mouths or entries, was in reciprocal proportion to the area of those holes; that is, as the area of the greater holes or inlets, to the area of the lesser holes or outlets, so the velocity of the motion of the air in the smaller holes, to the motion of the air in the greater. By this contrivance, it is easy to make a ball at the top of a steeple-turret, &c. that by

the air's blowing of a pipe contrived in it, the quarter and strength of the wind may at all times, either by night or day, be easily discovered. By somewhat a like contrivance also may be made an instrument for collecting the sounds dispersed in the air, into one small channel or pipe, to be applied to the ear, by which means the hearing may be much augmented and bettered.

It being mentioned in this description, that by a somewhat like contrivance there might be made an instrument for collecting the sounds dispersed in the air into one small pipe, to be applied to the ear, to serve for an otacousticon, it was ordered, that Mr. HOOKE should cause a great glass receiver to be made for that purpose.

Cider Engine.

Mr. HOOKE produced his newly contrived cider engine, which being tried, but found not to go close enough for expressing out all the juice of the apple at once, it was ordered, that it should be made to go closer against the next meeting.

Lens Grinding.

The business of improving optic-glasses being again spoken of, Mr. HOOKE observed, that Mr. COXE had affirmed to him, that he would make a spherical glass of the same power with those of Mr. SMETHWICK, declared not to be spherical, which should perform the same effects, of taking in as great an angle, and representing the object as distinctly and truly, as Mr. SMETHWICK's glasses. It was ordered, that Mr. COXE should be desired by Mr. HOOKE to make good his affirmation.

Incubator.

Mr. HOOKE produced a lamp-furnace for hatching of eggs in it. The experiment was ordered to be tried without delay.

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Bladder Stone.

Mar. 26. Mr. HOOKE was ordered to take the dimensions and draw the figure of the stone lately taken out of the bladder of Sir THOMAS ADAMS, which being weighed before the society, was found to weigh twenty-two ounces and three-eighths troy weight.

Night Glasses.

Mr. HOOKE gave a hint of making glasses, by which one might see and read in the dark. He was desired to think further of it, and to make some trials accordingly.

Ear Trumpet.

Apr. 2. Mr. HOOKE produced a glass receiver for the improvement of hearing. Being tried by holding the neck of it to the ear, it was found, that a stronger sound was conveyed by it, than would have been without it. It was ordered, that at the next meeting there should be brought a better and larger receiver for hearing.

Diving.

He mentioned, that there was a person, who offered his service to the society for diving; which offer was accepted of, and Mr. HOOKE ordered to consider against the next meeting of the apparatus for it, and of the experiments to be made by it.

Ear Trumpet.

Apr. 9. Mr. HOOKE produced two receivers, one of which was of latten, and of a conical figure, the other of glass and round, both sharp at one end. Being applied to the ear, the former was judged best for the increasing of sounds: Mr. HOOKE was ordered to take them home, and try them further by himself, and particularly during the silence of the night, and to bring in an account of their effects.

Diving.

Mr. HOOKE being called upon to declare what apparatus he had thought upon for the experiments of diving, to be tried by the diver, who offered himself, said, that there were formerly made diving-boxes, which he would put in order; and that the experiment necessary to be made first of all for this purpose was to try, which way the diver could continue a good while under water, so as to work there freely; which being once contrived so as to succeed, there would then offer themselves a great number of experiments to be made under water.

The experiments appointed for the next meeting were: 1. Those of weighing metalline bodies. 2. The cider engine ordered to be perfected. 3. Optic-glasses, both of Mr. COCKS in Long Acre, and of Mr. HOOKE, for seeing in the dark.

Colwell Collection.

Apr. 13. It was ordered, that Mr. HOOKE complete the printed list of the collection bestowed by Mr. COLWALL on the society; and that this list be inserted in the next edition of the *History of the Society*.

Tanning by Acorns.

Apr. 16. Upon occasion of the account given in a letter of the

way used in Turkey of dressing leather with acorns, Mr. HOOKE was ordered to suggest the like trial to be made with the English acorns by the tanners of London.

Ear Trumpet.

Mr. HOOKE produced again the large conical tin receiver for the magnifying of sounds; which being tried was found to make words softly uttered at a distance to be heard distinctly; whereas they could not be so heard without this instrument.

Structure of Muscle.

He produced a muscle, to show how it consists of mere fibres or strings lying close together, longwise, like the fibres of talc.

Respiration.

Apr. 30. Mr. HOOKE read his answer to Dr. WALTER NEEDHAM's letter concerning the experiment of preserving a dog alive by the wind of bellows, and by keeping the lungs distended with fresh air, though not moved. It was ordered, that the experiment mentioned by the doctor seeming to him to disprove the consequence deduced by Mr. HOOKE from his experiment, should be made at the next meeting, the curators and Dr. KING, appointed at the last meeting to make it at this, being absent; and that the operator should again speak to Dr. LOWER and Dr. KING to take care of the experiment at that time.

Circulation of Blood.

Mr. HOOKE proposed an experiment, to see, whether the blood circulates, when the lungs are subsided. He was desired to make it before the society.

He remarked, that it had been observed, that blood, though of a dark blackish colour, would, when exposed to the air, become presently very florid, and that florid surface being taken off, and the subjacent part exposed again, would acquire the like floridness; and that therefore it might be worth the observing by experiment, whether the blood, when from the right ventricle of the heart it passes into the left, coming out of the lungs, it hath not that tincture of floridness, before it enters into the great artery; which if it should have, it would be an argument, that some mixture of air with the blood in the lungs might give that floridness.

Queries for Turkey.

May 7. Mr. HOSKYNS and Mr. HOOKE were desired to consider against the next meeting of some further particular queries for Turkey to be sent thither by the next opportunity.

Circulation.

The experiment suggested by Dr. WALTER NEEDHAM in his letter of March 10, 1667/8, to prove, that an animal died rather for want of the blood's motion, than for want of a supply of fresh air, was ordered to be tried first in private by Dr. KING and Mr. HOOKE, who agreed to meet for that purpose on Saturday morning following, and to give an account of the success thereof at the next meeting.

The Royal Society's Building.

May 11. Mr. HOOKE was desired to bring in his draft for the building of the college, and an estimate of the charges thereof, on the Monday following.

Respiration.

May 14. Dr. KING brought in his account of the experiment ordered to be made by himself and Mr. HOOKE in private, of filling the lungs of a dog with air, and keeping the same air without any admission of fresh air: which account was ordered to be registered, as follows:

May 9, 1668, in order to your commands, we made the experiment of filling a dog's lungs full of air, and keeping the same air without any admission of fresh air, in this manner.

First having placed and tied the dog in a convenient posture, and being furnished with a large bladder, that had a short brass tube fastened to it, we filled the bladder with air by the help of a pair of bellows, (the air being kept in by two ligatures, one at each end of the bladder); then we cut off the aspera arteria, as near as we could conveniently to the epiglottis, and held it out by a thread: then we inserted our brass pipe into the aspera arteria, and tied it very fast in; which done, we immediately slipped the running-knot from about the bladder, that the air might have a free passage from thence into the lungs, which we presently perceived was sucked into the lungs by the elevation of the dog's thorax, and its return, upon contraction of the thorax, into the bladder again: but when the thorax was dilated, we compressed the bladder, that we might fill the lungs with as much air, as they were capable to hold, by such a force. In the meantime, the dog made the same endeavours for breathing with the same motions, as is usual; though with more difficulty and violence, (as to the force of contraction); for I could not continue my hands many minutes compressing the bladder, the air pressing so forcibly into it. After about three or four minutes, the dog began to struggle violently, and to repeat his endeavours for breath very frequently, with a nimble motion of the heart, but no convulsions; yet, after about six minutes, his strength failed

apace; his motions of the breast and belly were less frequent; his pulse languid and slow, but equal enough; and then he began to be convulsed; and at the end of about eight minutes, we could see no signs of life (though unbound) only now and then a feeble pulse: then concluding him very near death or just suffocated, we immediately slipped the other knot, and made room for the bellows to play again, to fill the lungs with fresh air, (cutting a little hole in the bladder to let out the air, that had been so long imprisoned in the dog's lungs and the bladder) and within less than a minute, the dog, by our moving the thorax first and continual blowing, recovered motion in his breast, and his pulse did rise strongly, he opened his eyes, and, in a little time more, got strength again, and breathed freely: so then we sewed up his throat, leaving the mouth of the aspera arteria open, and set him down, and he walked away. Then we untied his mouth, and he presently fell to licking of himself, as not much concerned: but we all concluded, that if we had stayed but one minute more, before we let in fresh air, in all probability the dog's life would have been quite lost.

Dr. KING and Mr. HOOKE were desired to repeat this experiment, and then let the dog lie two or three minutes longer, when they should judge him as much dead, as they did at this time, that so the trial might be beyond exception.

Hydrostatics.

Mr. HOOKE made an experiment of statics, to show the penetration of liquors: first, there was a ball of glass poised in the air, and then it weighed three hundred and two grains and a half: the same ball in fair water weighed one hundred and fifty grains and seven-eighth parts: in oil of vitriol twenty-four grains: in a mixture of an equal quantity of oil of vitriol and fair water seventy-three grains and a half. It was ordered, that a full account of this be brought in by Mr. HOOKE.

Arundel Library.

May 18. Mr. HOOKE was desired to bring in at the next meeting of the council an account of the number of books of the Arundel Library, and to meet with Dr. BALLE on the Saturday following for the completing of the catalogue of that library.

Hydrostatics.

May 21. Mr. HOOKE brought in his account of the statical experiment of the penetration of liquors made at the preceding meeting; which was ordered to be registered, as follows:

This experiment was made with a very good pair of scales, which would turn with a small part of a grain, though the differ-

ence of weight was sensible enough to be discovered by a more gross and unaccurate beam. The manner of the experiment was this: there was taken a small ball of glass, somewhat bigger than an inch in diameter; this was made heavy enough, by white lead put within it and sealed up, to sink in strong oil of vitriol. This was suspended by a very fine wire, under one of the scales, and the weight of it exactly taken in the open air, which was found to be $302\frac{1}{2}$ grains. After this, a glass of fair water was put underneath it, and the ball suffered to sink into it, and being again exactly counterpoised, whilst in this medium, it was found to weigh $150\frac{7}{8}$ grains. Then the water was removed, and, instead thereof, a glass of oil of vitriol was underplaced, in order to examine the gravity of the former ball in this liquor, and it was found to be 24 grains. Then taking an equal quantity of oil of vitriol and fair water, they were by degrees put together, which working upon each other, caused a very great heat, till both of them were incorporated and perfectly united into one liquor: then, being suffered to cool, they were put into one of the former glasses, and set under the end of the scale, and the same ball was suffered to sink into it, and was then exactly counterpoised, and found to weigh $73\frac{1}{2}$ grains; whence the proportion of the weights of the water, oil of vitriol, and mixture were as $151\frac{5}{8}$–$278\frac{1}{2}$–229: Which is a certain experiment, that liquors are porous, and that they can penetrate each other, so that both of them put together take up a much less room, than when separate; for whereas, according to the former experiments, it ought only to have weighed $215\frac{1}{16}$ grains, if there had been no incorporating of these two liquors, it was now found to weigh $13\frac{15}{16}$ grains heavier in specie, than it would have done, if there had been no penetration. This kind of experiments may be of great use, and afford an excellent clue to lead one further into the recesses of nature, and to inform us of the internal texture and component parts of bodies: For the prosecuting of which inquiry, it were very good to examine the weight of several sorts of liquors, both mingled and apart; to examine the weight of liquors, both before they have dissolved metals, stones, juices of seeds, plants, &c. and when they are impregnated with the newly mentioned substances, and by some other liquors, whose comparative gravity has been also examined, to precipitate those dissolved substances; and to examine the weight of that compounded liquor that remains. For by such examinations, great light may be obtained for the finding out the nature of dissolving and precipitating liquors, and other liquors, that penetrate each other.

The experiment made at this meeting was another statical one with aqua-fortis and iron. Mr. HOOKE coming late, the ex-

periment, which required much time, could not be finished, and therefore was referred to the next meeting.

Respiration.

May 28. Dr. KING acquainted the society, that he with Mr. HOOKE had repeated the experiment appointed to try, what time a dog would live without fresh air, observing the direction given at the last meeting about it; and that it had killed the dog; as also that he had tried another anatomical experiment in private, of both which, at the society's desire, he promised to bring in a written account at the next meeting.

Mr. HOOKE was ordered likewise to try in private the experiment of the floridness of the blood, when passed from the right ventricle of the heart through the lungs into the left ventricle; and Dr. KING was desired to join with him in it.

Variation of Magnetic Needle.

[After a letter on observations by Capt. S. STURMY made near Bristol on the variation of the needle had been communicated] it was desired, that those members of the society, who had conveniency and proper instruments, would take care of making the like observations in London in the approaching month of June; as also to observe the solstice; to the doing of which the President, Sir PAUL NEILE, Mr. BALLE, and Mr. HOOKE were particularly desired to attend.

Hooke's Assistant.

May 30. Mr. HOOKE acquainting the council, that he had now met with a man fit to be employed in the labour of making experiments for the society's service, who would be contented with twenty pounds a year for it; and declaring also, that if he had the service of this man, he would not fail to bring in three experiments every meeting; the council ordered thereupon, that Mr. HOOKE should take this man for a quarter of a year's trial after the rate of the sum expressed; and that the said servant should be employed not only by him, but also by such other fellows, as should have occasion for him upon the account of the society, in making of anatomical or other experiments.

June 4. Mr. HOOKE not being present, the experiments appointed for this meeting were referred to the next.

Nitrate of Mercury.

He was ordered to bring in a written account of the experiment made May 28, with aqua-fortis glutted with mercury.

Seed of Moss.

June 11. Mr. HOOKE brought in a written account of the seed of moss, observed by him to be of that exceeding smallness, that above seven hundred and seventy millions are required to make the weight of one grain; the method of computing which he explained. This paper was ordered to be registered, as follows:

Since the publishing of my *Micrography*, I have met with an observation, which, though it be of one of the smallest compound bodies I have hitherto taken notice of, yet does afford an hint of very great concern in natural philosophy; and it does seem to make clear the cause of a phenomenon, that has appeared dubious, not only to me, but to many other more knowing naturalists. I have often doubted, I confess, whether moss, mushrooms, and several other small plants, (which the earth seems to produce ἀυτομάτῃ) were the offspring of a seed or grain, and have been apt to believe, that they were rather a secondary production of nature; being somewhat the more inclined to be of that opinion, because having formerly examined the small knots of seed-cods of moss with a single microscope, I could not perceive anything in them, that I could imagine to be seeds, at least not so great a quantity, as seemed necessary to maintain so numerous a progeny, as was everywhere to be found of it; that, which then came out of them, seeming to be rather a pulp or pith, than anything like the seeds in other similar cods. But being since somewhat more inquisitive, I did examine several of the abovementioned knobs or seed-vessels, and found, that there were seeds in them, no less wonderful for the greatness of number, than for the smallness of bulk. Taking then some of the ripe and brown or reddish ones of them, and pressing them pretty hard, I found, that there was a small dust went out of them, which seemed to vanish in the air. Pressing and squeezing others of these upon a black plate, and examining the powder with a microscope, I found it to be a great heap of exceeding small seeds, globular, and pretty transparent: it is the smallest, I confess, I have yet seen, and, it may be, that has hitherto been discovered. And unless that be a plant, which I discovered growing on the blighted leaves of roses, and that those small bodies be seed-vessels; or unless those knobs, I have discovered on the top of mould, be the like, I cannot presently imagine, where there should be found a smaller. For I find, that there will need no less than thirty-six hundred of them to be laid one by another in a line, to make the length of an inch, in the same manner as three barley-corns are laid to measure an inch: and to cover a superficies of an inch square, there will need no less than nine hundred and threescore thousands, besides twelve millions of single seeds: and the number in a grain weight of them cannot be less than seven

hundred and seventy-seven millions besides six hundred thousand single grains. And though this may seem a most incredible narration, yet I would desire such, as are apt to be too censorious, to take the pains to gather a few of those seed-vessels, and examine them as I have done, and then speak what they find, and believe no more than their own sense and reason will inform them; and they may easily see, that what I have asserted, will be rather short of, than exceed the real numbers. Now if this shell of the seed be thus small, how much smaller must needs the rudiment of the plant, that lies enclosed within it, be? and how easily may such seeds be drawn up into the air, and carried from place to place even to the top of the highest towers, or to places most remote, and be sowed by the passing air, or falling drops of rain, on the bows or branches of trees, sides and tops of walls, houses or steeples? And it is not in the art of man, to leave earth exposed to the common air, and to exclude the entrance, or prevent the sowing of these imperceptible seeds; and therefore it is not to be wondered at, that, if any earth, though never so pure, be exposed to the air and rain, though at the top of a steeple, it will produce moss. Further inquiry may possibly instruct us, that there may be seeds of mushrooms, mould, and other vegetables of as small, if not smaller, bulk, which may be dispersed and mingled with the air, and carried to and fro with it, till washed down by the falling drops of dews or rains, which, if they chance to light on a convenient soil, do there vegetate and spring up; but die and perish, if the ground, they light on, be not natural and agreeable. But whether this conjecture hit right, further observation must determine.

Valves for Ascent of Plant Sap.

Mr. Hooke suggested, that it was worth inquiry, whether there were any valves in plants, which he conceived to be very necessary for conveying the juice of trees up to the height of sometimes 200, 300, and more feet; which he saw not how it was possible to be performed without valves as well as motion.

Expansion of Bodies.

He brought a written account to show the dilatation of bodies, whereby they are made to fill a larger space than they did before, not only when they are hot, but when perfectly cold. It was ordered to be registered, as follows:

I have formerly given an account of an experiment I made before this illustrious society, to show the reducing of bodies into a more condensed state, as to the position of their constituent parts; namely, in the experiment of the corrosion of water by oil of vitriol; which dissolvent being heavier than the

body dissolved, we find, that the compound was heavier in proportion, than it ought to have been, if it had been only a single mixture. I now come to give an account of an experiment, to prove the apertion, expansion, or rarefaction of bodies, whereby they are made to occupy and fill a larger space than they did before; and this, not only when they are hot, but when perfectly cold: so that they must needs have acquired a new tone or texture of their constituent parts, and such a one, as (if rarefaction proceeds from dispersed vacuities) must needs contain void spaces, greater either in quantity or number, than their former texture admitted. And this is, where the menstruum is lighter than the substance to be dissolved. The experiment was this; the comparative weight of aqua-fortis was found by the glass ball and scales formerly mentioned; after which, half the weight of mercury was dissolved by it, and then the comparative weight of that mixture was tried by the same means, and the weights were found these that follow:

Ball in air	307 grains.
An equal quantity of aqua-fortis	207 gr.
A quantity of water equal in bulk to the ball . .	152 gr.
A quantity of ☿ equal in bulk to the ball; ☿ being to water as 14 to 1.	2128 gr.
Therefore a quantity of the liquor compounded of aqua-fortis and half the weight of ☿ should have been .	$300\frac{9}{14}$ gr.
But it was found to be only	285 gr.

which is 15 grains lighter than it ought to have been, if, at least, the proportion between water and quicksilver be as 14 to 1.

Porosity of Sand and Ashes.

An experiment was made of the porosity of sand, being first well shaken and pressed together, to see, how much water it would take in afterwards. The sand was white hour-glass sand, and the quantity here used weighed nine ounces six drachms. The sand and water imbibed weighed both together eleven ounces one drachm and a half.

Mr. Hooke was ordered to bring in writing a full account of this experiment, and to try the like about the porosity of ashes at the next meeting; as also the experiment of weighing sal-gem in oil of turpentine.

Arterial Blood.

Mr. Hooke was reminded of making the experiment concerning the floridness of the blood in the arteries, after it had passed through the lungs.

Specific Gravity of Sal-gem.

June 18. An experiment was made of mixing sal-gem with

water, to see how much it would grow heavier thereby. There were taken one part of sal-gem and four parts of water by weight:

	oz.	gr.
The salt weighed in air	$1\frac{3}{4}$	$10\frac{1}{2}$
The same weighed in oil of turpentine	$\frac{3}{4}$	47
The glass ball weighed in the mixture of the said salt and water	$\frac{1}{4}$	$17\frac{1}{2}$
The same ball weighed in oil of turpentine	$\frac{1}{4}$	$53\frac{1}{2}$

Mr. HOOKE was ordered to calculate the proportion of these weights, and to bring in a written account of the whole at the next meeting; as also that of another experiment formerly made of this nature.

New Barometer.

Another experiment made was of a new kind of barometer, filled partly with quicksilver, partly with water, to the end, that the variations thereof might be rendered more sensible than they are in those glasses, which are filled with quicksilver alone. Mr. HOOKE was desired to bring in the description of this barometer in writing.

It was remarked by him, that the liquor in this kind of barometer will sometimes rise to thirty-four inches; of which he did not yet see the reason.

The President was desired to get such a barometer as this prepared, and to make observations; which his lordship promised to do.

Seed of Moss.

The smallness of moss seed being again spoken of, and Mr. HOOKE being desired to explain further what method he used in computing, that the weight of above 777 millions of those seeds makes no more than the weight of one grain, he added to what he had already said in his written account of it, that he reckoned, that two inches square of Venice paper weighed one grain; and the length of thirty seeds laid close by one another equalled the thickness of Venice paper: which being calculated after the manner described in his written account would amount to the sum above mentioned.

Mr. HOOKE being asked what kind of moss it was, the seed whereof he had thus examined, said, that it was of that sort, which he had described in his *Micrography*.

Microscopic Growths on Leaves.

Mr. CHARLES HOWARD was desired to bring in what capillary plants he had for Mr. HOOKE to view with a microscope the backs of the leaves of them, in order to observe what substances they are, that grow on them.

Growing Moss on a Dead Man's Skull.

Dr. Wilkins moved, that Mr. Hooke might be ordered to try, whether he could by the means of the moss seed shown by him make moss grow on a dead man's skull.

Royal Society's Building.

June 22. The draft of the building for the Royal Society being examined and agreed upon, Mr. Hooke was ordered to get a model of it made with one door, and to consider of the buying of the materials, and of contracting with workmen, to be paid by measure for so much a rod and square: as also to find out a person to be constantly present; and to see the workmen do their duty.

Repository.

It was ordered, that the Treasurer pay to Mr. Hooke fourteen pounds ten shillings for fitting the place in Gresham College for the society's repository, according to his bill.

Microscopic Structure of Wood.

June 25. Mr. Hooke brought in a microscopical observation concerning the texture of wood, tending to show the manner of the juices ascending to the top of tall trees by a kind of valves: But the society not being satisfied with the observation made this day by a microscope of a piece of wood, it was ordered, that it should be referred to a clearer day, and that a better microscope should be provided for that purpose: as also that Mr. Hooke should look on a bullrush, to observe how the texture of that appears to be.

Royal Society's Building.

June 29. Mr. Hooke was ordered to bring in at the next meeting of the council an estimate of the charge both of the materials and workmanship of the building.

Dr. Wilkins and Mr. Hooke were desired to speak with Mr. Nelthrop about timber.

July 6. It was ordered, that Mr. Hooke make a draft for the building of the college, representing the front thereof to the Thames, and to draw it with the windows, Mr. Howard having declared, that it was indifferent to him, which way it stood, so it might be contrived for the conveniency of the society.

Mr. Hooke was again ordered to prepare the workmen, and to look after materials; as also to make an estimate of the charges, according to this last position of the building.

Respiration in Compressed Air.

July 9. Mr. HOOKE proposed an experiment to try in an instrument for compressing the air, how much longer a bird would live in the compressed air of a glass, than in the ordinary air of it. Accordingly a bird was put into the glass with ordinary air at six minutes past five o'clock, and taken out at thirty minutes, when it began to be sick. Being taken out and recovered, it was put in again at forty minutes, and three-quarters of the air was compressed upon it in the space of eleven minutes by the gauge. The bird was kept in this condensed air for thirty-three minutes, and seemed to be very well. But the instrument not being staunch, it was ordered, that the experiment should be repeated at the next meeting, so as to provide divers glasses of several dimensions, and some birds of the same kind, to see, whether there would be an equal proportion between the time of the bird's life, and the quantity of air in the glasses.

Combustion in Compressed Air.

Mr. HOOKE affirmed, that an experiment had been formerly made by order of the society, as would appear by their journal, where a burning lamp lasted much longer in compressed than uncompressed air. The amanuensis was ordered to consult the journal for that purpose against the next meeting.

The Building.

July 13. There were examined two drafts for the building of the college, both fronting to the water, one of Mr. HENRY HOWARD, the other of Mr. HOOKE. The determination, which of them should be followed, was referred to the next meeting of the council, at which Mr. HOWARD was desired to bring in his design of ordering the whole plot of his ground.

New Level.

July 16. Mr. HOOKE produced a new kind of level invented by himself, with a piece of glass bent into a curve, having this advantage above other levels, that it is of a true figure; other levels made with glass canes not being so. But because the water and bubble of air in the water is subject to rarefaction and condensation, it was thought necessary, that another liquor should be employed, that is not so. It was ordered, that one of those levels should be made for the repository, and a description thereof brought in for the register.

Fossil Shark's Teeth and Shells.

Mr. HOOKE produced some petrified bodies vitriolated, which he affirmed to be the teeth of sharks.

He remarked likewise, that he had found many shells in Portland stones; and that at that very time it might be seen in such stones lying about the Royal Exchange.

Formation of Nitre.

Mr. HOOKE upon occasion intimated, that he thought alkalis being exposed to the air would arrest the volatile salt, which is in the air, and turn it into nitre.

Fossil Teeth.

July 23. Mr. HOOKE presented for the repository several petrified teeth, said to have been found in Sheerness, and there taken out of a rock on the sea-side, conceived to have been the teeth of shark-fishes.

The Florentine Experiments.

Dr. MERRET was called upon for the account, which he had promised March 26, to give of the book of the Florentine experiments; and he excusing himself, that the book had been sent for by Mr. HOOKE, before he had made an end of perusing it, Mr. HOOKE was desired to return the book to the doctor.

Use of Pith.

July 30. Mr. HOOKE suggested, that it should be tried, of what use the pith in plants might be, by stopping the pith, or cutting it.

Vessels in Wood.

He affirmed, that he had observed, that charring of wood showed other kind of vessels than the rotting of them did.

Pores in Wood and Ascent of Sap.

Aug. 6. A microscopical observation, devised by Mr. HOOKE, was made on a little lump of charcoal of fir-wood, in which appeared here and there interstices or partitions intersecting the great pores. Several of the members saw it, and were satisfied. Mr. HOOKE affirmed likewise, that some of the smallest pores had the same interstices; and added, that he was inclined to believe, that there were valves in wood, since it appeared not possible, that in trees of two or three hundred feet high (as there are such between the tropics) the sap should ascend to that height by filtration, which carries liquor no higher than thirty-six or forty feet.

Mensuration of the Earth and Parallax.

In the meantime Mr. HOOKE was ordered, during this vacation, to make the experiment in the Park for the mensuration of the

earth; and that of observing the parallax of the earth's orb: and it was recommended, that the committees of the society might meet as often as conveniently they could.

August 17.

(19) *A contrivance to make the Picture of anything appear on a Wall, Cub-board or within a Picture-frame etc., in the midst of a Light room in the daytime; or in the Night-time in any room that is enlightned with a considerable number of Candles; devised and communicated by the ingenious Mr. Hook.*

Phil. Trans., No. 38, pp. 741–3, August 17, 1668.

Sept. 15. On this day Mr. HOOKE ended his *Lectures and Discourses of Earthquakes* and *subterraneous Eruptions explicating the rugged and uneven Face of the Earth, and what reasons may be given for the frequent finding of Shells and other Sea and Land petrified Substances scattered over the whole Terrestrial Superficies.*[1]

Parallax.

Oct. 22. It being considered what experiments should be tried henceforth, the President mentioned, that he had understood, that Mr. HOOKE had erected a tube to try, whether he could observe to a second minute the passing of any fixed stars over the zenith, and thence find a parallax of the earth's orb, in order to determine the earth's motion.

Nature of Motion.

After this it being proposed by Mr. HOOKE, that the experiments of motion might be prosecuted, thereby to state at last the nature and laws of motion, the President desired, that it might be considered, whether it were so proper or necessary to try this sort of experiments, since Monsieur HUYGENS and Dr. CHRISTOPHER WREN had already taken great pains to examine that subject, and were thought to have also found a theory to explicate all the phenomena of motion.

Measuring a Second of Time.

Oct. 29. Mr. HOOKE produced an instrument for measuring a second of time by the sun, or for making the motion of the sun to be perceived every second. It not being yet perfect, he was desired to make it so against the next meeting.

[1] *Posthumous Works*, pp. 277–328.

Solar Eclipse.

He acquainted the society, that all the observations, that he could make of the late eclipse of the sun, which happened the 25th instant, was only to see the beginning of it, which was *h.* 11. 5′. *matut.* and a few seconds: whereas WING in his almanack had calculated the beginning *h. matut.* 11. 17′. 58″.

Bodies Falling in Vacuo.

An experiment was tried of falling bodies in a glass cane about four feet long, exhausted of air, in which a feather let fall came down to the bottom in four seconds: but when the air was re-admitted, in six seconds. The glass not being well exhausted, and too short, it was ordered, that a longer glass should be provided against the next meeting, and care taken, that it might be then better exhausted.

Mr. HOOKE mentioned an experiment made by Mr. BOYLE of including bellows in a glass exhausted of air, to see, what effect the bellows working would have on the subtile matter remaining in the vessel; and whether it would cause any agitation therein.

Mr. HOOKE moved, that experiments might be made to see, whether all hard bodies, that rebound, do not so upon the account of having springy particles in them; and that it might be inquired into, whether there be any body springy upon any other score, than that it has air in it.

He conceiving, that if there were to be had a body absolutely hard, and destitute of all springiness, it would not rebound at all, and it being said, that such a body would not be easily found for making the experiment, he answered, that it might be tried comparatively.

He took notice, that glass was capable of condensation and relaxation by pressure, and by taking off that pressure; and that the parts of glass may be put into a closer posture, because they contain air in them.

Feather Falling in Vacuo.

Nov. 5. Mr. HOOKE made an experiment of letting a feather fall in a glass cane of about seven feet long with a head upon it; which being well exhausted, the feather fell down from the top to the bottom in about three seconds of time; but being again filled with air, the feather fell down in seven seconds and a half. Both experiments were repeated several times, with near the like effect.

Impact of Balls.

Mr. HOOKE proposed the trying of experiments to determine

the question concerning the communication of motion. For which purpose some trials had been made formerly with three or more wooden balls, of which one of the lateral ones had been let fall against the middlemost, and impelled the other lateral one to the like height, from whence the first was fallen, so that the middlemost stirred but very little. He promised to prosecute these experiments at the next meeting by employing more balls, and letting the exterior ones fall against the intermediate.

New Star in Cete.

It was recommended to Mr. HOOKE and others, who could conveniently, to take notice of this phenomenon, the new star in Cete.

Impact of Balls.

Nov. 12. The experiment of the communication of motion was tried by a contrivance, whereby three balls of the same wood, and of near equal bigness, were so suspended, that either of the two extremes being let fall from a certain height against the intermediate ball, the other extreme was impelled upwards to near the same height, from whence the first was let fall, that in the middle moving but very little; of which the President conceived this to be the reason, that the intermediate ball, when struck by one of the lateral ones, found the resistance of the other lateral ball; but this other lateral ball met with no other resistance than that of the air.

Further Experiments thereon.

Mr. HOOKE was ordered to think upon other experiments for the making out this hypothesis about motion, which is, that no motion dies, nor is any motion produced anew.

Impact.

Nov. 26. The experiment devised and made this day by Mr. HOOKE was the impelling of wooden balls against both springy and not springy bodies, whereby he intended to evince, that the reflection of motion depends upon the springiness of bodies; so that where there is no spring, there can be no reflection.

But the experiment made not being satisfactory to the society for the purpose declared, Mr. HOOKE proposed another to be made at the next meeting, viz. with a metalline string made more or less true, to see what the returns or reflections of it will be, according to its several degrees of tension.

Operation on Kidney.

It was agreed upon, that the committee for anatomical experiments should meet on the Saturday following at Mr. HOOKE'S

lodgings in Gresham College, in order to make an incision in the kidney of a dog, and to observe, whether it would heal up again.

Javan Curiosities for Repository.

Nov. 30. Sir ROBERT MORAY produced a present sent to the society by Sir PHILIBERTO VERNATTI from Batavia in Java Major. The things were delivered to Mr. HOOKE for the repository; but the reading of the paper describing them was referred to the next meeting.

Dec. 3. The present sent by Sir PHILIBERTO VERNATTI was opened; and the paper describing the particulars, as also an answer to some queries, were read; both which were ordered to be registered, and a copy of the description of the curiosities to be given to Mr. HOOKE, to be kept together with them in the repository.

Two-headed Amphibaena.

It being, among the answers to the queries, affirmed, that the answerer himself had seen an Amphibaena with two heads, Dr. POPE and Mr. HOOKE said, that Sir ANDREW KING had seen divers of them in Spain.

Impact.

Dec. 10. The experiment devised by Mr. HOOKE, to show, how rebounding depends upon the springiness of bodies, was made by a springy plate of brass, bent in the form of an oval; which being cut or burnt asunder reflected two wooden balls of different sizes; so as that they were conceived to move in reciprocal proportion to their magnitudes. The experiment was ordered to be prosecuted at the next meeting.

Allen on Testes.

Mr. HOOKE informed the society, that Dr. ALLEN had examined the testicles of a horse, and found them to be made up of vessels.

Jupiter's Satellites and Cassini's Ephemerides.

Mr. HOOKE acquainted the society, that he had lately made an observation of one of the eclipses of Jupiter by the satellites, and that it had happened at the very time, assigned by CASSINI in his *Ephemerides Mediceorum.*

He moved, that Mr. OLDENBURG might be desired to write to CASSINI, to learn, whether he had calculated other ephemerides of any year to come; and if so, to request him to communicate them, in order that observations might be made in England as well as Italy, to find out the precise difference of meridians.

Mr. OLDENBURG accordingly undertook to write to him for that purpose.

Elasticity.

Dec. 17. An experiment was made in prosecution of the motion, that springiness is the cause of rebounding; viz. a wooden globe was let fall against wood, a gut string, and a brass wire.

Reflection of Light.

Mr. HOOKE took occasion to mention, that he thought, that air, next to quicksilver, gave the quickest and most forcible reflection; and that the sparkling of diamonds in rings proceed from the air left behind the stones.

Mr. HOOKE was ordered to take care, that the experiments be made before the society, to verify the several cases relating to the theory [of the collision of bodies] produced by Dr. WREN.

Springiness.

He was desired to bring in what he had considered of the cause of springiness.

Air Resistance.

Dec. 31. Mr. HOOKE affirmed, that he conceived, that the impediment given by the air or other fluids to moving bodies decreased in a continual proportion: which the President desired might be made out by experiment.

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Experiment on Motion.

Jan. 7. Mr. HOOKE made an experiment to prove, that the strength of a body moved is in a duplicate proportion to its velocity. But the experiment not succeeding, by reason (as was supposed by Mr. HOOKE) of the frost disordering the instrument employed, it was ordered to be repeated at the next meeting.

Lenses.

He showed a way, whereby a segment of a spherical glass may be made to magnify the object to the very edges, and so to perform the effect of a conic section. It was observed by several of the members, that it succeeded accordingly, it being performed by means of water poured upon the spherical glass. Mr. HOOKE was desired to show it again at the next meeting.

Experiments on Motion.

Jan. 14. Mr. HOOKE showed by two sorts of experiments, that the force in moving bodies is in a duplicate proportion to

their celerities, so that there is required a quadruple weight to double the velocity.

The first sort was made by a pendulum, made after the manner of a fly, counterpoised; which was several times repeated with the success expected, there being made twelve vibrations with the weight of two ounces, and twenty-four vibrations with eight ounces, and forty-eight vibrations with a two-pound weight, all in the same time.

The other sort was with running water, whereby it appeared, that the falling water was to be raised four times the height to run out with double the celerity. This latter was ordered to be repeated at the next meeting, because the vessel leaking hindered somewhat the exactness of the experiment.

Horizontal Wheel.

Mr. HOOKE produced an instrument with a wheel to perform the same thing in an horizontal position: which was ordered to be tried at the next meeting.

Pendulum.

Jan. 21. Mr. HOOKE affirmed, that the vibrations of a pendulum of eight feet long with a weight of eight pounds (which was of a conical figure) lasted about eight hours.

Jan. 28. Mr. HOOKE made an experiment, tending to show, that a body, once put in motion, would move perpetually, if it met not with resistance. This he did by hanging a wheel, having a pointed piece of iron in it, on a capped loadstone, and putting it into motion by a pair of bellows; whereby the wheel continued its motion for a considerable time, as having but little resistance, which was no other than that of the air, in which it moved round.

It was suggested, that it were worth observing, how the velocities of this motion decreased in equal times.

Arrears of Salary.

Feb. 1. It was ordered, That the Treasurer do pay to Mr. HOOKE the arrears due to him, according to the allowance appointed him by the order of council of November 23, 1664, of thirty pounds a year.

Feb. 11. Mr. HOOKE being absent, the experiments of motion were not prosecuted.

Cock's great Microscope.

The operator was ordered to speak to Mr. HOOKE, that the new great microscope of Mr. CHRISTOPHER COCK's making be brought to the society at the next meeting.

Power of Magnets and Magnetical Watch.

Feb. 25. Mr. HOOKE proposed an experiment to find out, how the magnetical power decreases at several distances, and promised to bring in at the next meeting a watch, the balance of which should move by the force of a magnetic steel.

Malpighi on Silkworms.

Mr. HOOKE reported, that he had perused Signor MALPIGHI's discourse of silkworms, and found it very curious and elaborate, well worth printing. This was seconded by Mr. OLDENBURG, who thereupon read the letter, which he had drawn up for Signor MALPIGHI, thanking him for his great respect in dedicating the said discourse to the society: which letter was approved of, and ordered to be entered in the letter-book.

Magnetical Watch.

Mar. 4. The experiments appointed for the next meeting, besides those above mentioned, were Mr. HOOKE's magnetical watch, and that of falling mercury in a glass cane.

Experiments on Motion.

Mar. 11. The experiments of motion made at the last meeting being again spoken of, the President intimated, that the result of them seemed to be, that the heavier body fastened to the round plate maketh the greater excursion, and therefore continueth the longer; but that still it remained to be inquired after, what was the precise resistance of the air to bodies moved through it.

The prosecuting and varying these experiments, by applying the same weight to several bodies, which should have been done at this meeting, was referred to the next, and Mr. HOOKE was ordered to take care, that then it might be done.

Magnetical Watch.

It was also moved, that he should bring in his new contrivance of a watch, said to move by a balance touched with a magnet.

Observations on Frogs and their Spawn.

Mr. HOOKE remarked, that he had examined some frogs, and found in them a seminal and excremental vent: and that he had looked upon the black round spawn of frogs by a microscope, and thought, that he saw a whitish tegument round about the black substance, and was of opinion, that that was like the white of an egg, as he guessed the black matter within to be instead of the yolk. He undertook to observe the progress of frogs' spawn from time to time.

Magnetic Watch.

Mar. 18. Mr. Hooke tried something in order to make a watch go by the force of a loadstone. It was ordered, that he should provide against the next meeting an house-clock, going half-seconds, and put a flight upon it, to try what the power of the magnet would be.

It was remarked, that if this contrivance should be made practicable, the magnet would then furnish the navigator with the longitude, as well as it had hitherto served him with the latitude.

Transfusion of Blood.

Dr. Croone proposed an experiment, to try, whether an animal would be fed by blood alone transfused into it, viz. by enclosing two dogs in a box, and making the blood circulate from the one to the other by way of transfusion, feeding the one and not the other. He was desired to make the experiment, and Dr. Allen and Mr. Hooke to assist him in it.

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Physiology of the Circulation.

Apr. 8. There was made one of the experiments appointed at the last meeting, viz. that with guts blown up, and tied on both ends, to show, that for making a pulse in the arteries there needs no more than a compression in the heart, since the gut being compressed on one end, the motion of it was sensible at the other.

Dr. Goddard objected, that this was not sufficient to make out what was intended, since there was no outlet in these guts; whereas there is an issue of the blood in the body of animals out of the arteries into the veins.

Mr. Hooke answered, that there is so, yet there being a return of the blood to the heart again, it could not be otherwise, but that, the vessels being full, there would upon the circulation of the blood into the heart again and its systole, be caused a pulsation in the arteries.

He proposed an addition of a pipe to this experiment, the better to show the truth of his assertion.

Object Glasses for Microscope.

He produced some plano-convex spherical glasses, as small as pins' heads, to serve for object glasses in microscopes. He was desired to put some of them into the society's great microscope for a trial.

Texture of Muscle.

He proposed likewise an observation to be made of the texture of muscles by a microscope, which he promised to make for the next meeting, and then show it to the society.

Magnetic Watch.

Apr. 15. Mr. HOOKE exhibited again the experiment of the watch moved by a magnet, which, according to its several distances from the flight fitted to the watch, made it go faster or slower.

It was ordered, that a piece of clockwork with a spring going seconds should be provided for the next meeting, to be tried with a loadstone.

Apr. 29. Mr. HOOKE produced his magnetical watch improved by having so contrived the magnetical balance, which was instead of a pendulum, as to make it vibrate as little arches, as should be desired, thereby to make the vibrations always equal, and the magnet to have stronger influence upon the said balance.

It was again ordered, that a hand showing minutes and seconds should be added to it, thereby to compare it with a pendulum, for an assurance of its going equal.

Time-keeper.

Mr. HOOKE mentioned, that he had still another way of measuring time exactly, wherein a sudden turning motion should not cause a stop or disorder, as it did in this way.

Microscopic appearance of Fat and Mould.

Two microscopical observations were made, one of the texture of fat, which appeared to be like froth full of cells; the other of a kind of mould upon bookbinders' paste, which was found to have a fine moss growing on it, that had on the tops of its stems a head-like seed.

New Pendulum.

May 6. Mr. HOOKE produced a new kind of pendulum of his own invention, having a great weight appendant to it, and moved with a very small force; viz. by such a contrivance, that a pendulum of about fourteen feet long, so as a single vibration of it is made in two seconds, with an excursion of half an inch or less, having a weight of three pounds hanging on it, and moved by the sole force of a pocket-watch, with four wheels, shall go fourteen months, and cause very equal vibrations.

He showed two several contrivances for it; one was with a pin upon the balance of a pocket-watch, making a bifurcated needle to vibrate on one end, and on the other end the pendulum:

Another was with a thread fastened on one end to the balance of the watch, and on the other end to the pendulum, and so moving it to and fro.

Mr. HOOKE was ordered to cause one to be made for the society, closing the pendulum in a glass tube with a bolt-head beneath.

Solar Instrument.

He produced his instrument of observing second minutes by the sun, by a small telescope fastened on a board, and casting the picture of the sun, without a penumbra through it, upon an arch of wood covered with white paper, fastened to the opposite side of the board; an instrument of excellent use to observe eclipses. He was ordered to cause the arch to be divided against the next meeting.

Magnetical Watch.

May 20. Mr. HOOKE produced again his magnetical watch so improved, as he said, that it should move in all positions, with any kind of motion, without stopping, or being disturbed. He communicated the way of this improvement to the President, being not yet free to declare it in public, till he had brought it to perfection.

It was again ordered, that a minute-hand should be fitted to it, to see the equality of the vibrations.

May 27. Mr. HOOKE produced again his magnetical watch with a minute-hand upon it; which being tried was found not to go very just; the cause of which defect was conceived to be in the pinion, that carried the hand: which defect was ordered to be amended.

Elliptical Lenses.

June 3. Mr. HOOKE mentioned, that he had a method of grinding elliptical glasses, which he would shortly communicate.

Engine for Lens Grinding.

June 10. It was ordered, that the paper containing Dr. WREN'S demonstration of grinding hyperbolical glasses should be registered, and an engine be made by the care of Mr. HOOKE, to try the principle in matter.

Mr. HOOKE produced the model of another engine contrived by himself, so as to work a glass into any elliptical or hyperbolical figure assigned, by two motions, one upon the centres, the other upon a flat.

Some objections were made against it; but an engine was ordered to be made for trial.

Ordered to have Experiments ready.

June 17. Mr. HOOKE excused himself for having prepared no experiments for this meeting. He was ordered to take care, that against the next either his own new instrument for working elliptical glasses, or that of Dr. WREN for grinding hyperbolical ones, might be ready; as also that a couple of long pendulums, to be moved by the force of a pocket-watch, be prepared, to see how long they would go even together.

Sounding Machine.

It was moved also, that that instrument might be fitted for the Lord HOWARD, which had been formerly contrived by Mr. HOOKE for fetching up from the bottom of the sea what might be there, as stones, shells, plants, &c. which is done by a couple of springs shutting and catching as soon as the instrument touches the ground.

Engine for Grinding Lenses.

Mr. HOOKE mentioned, that he hoped to be now able to rectify the engine formerly contrived by him for the well-grinding of great spherical glasses so as to free it from those defects, which were hitherto discovered therein: which he was encouraged by the society to put in execution.

Meridian and Magnitude of Earth.

The President put Mr. HOOKE in mind of making a true meridian for observing the present variation of the needle; and also to make at last the observation, formerly recommended to him, concerning the magnitude of the earth.

Pendulum.

July 1. Mr. HOOKE taking notice of the remark made on his long pendulum moved by a pocket-watch, viz. that the smallness of the vibrations renders the pendulum more sensible of the impression, which the watch makes upon it, said, that the weight appendant to the string was so great, that that impression could have no power upon it.

Experiments.

After this came in the Venetian Ambassador, Signor MOCENIGO, to be present at the experiments appointed for this meeting, which [included] these:

1. The magnetical watch of Mr. HOOKE, going slower or faster according to the greater or less distance of the loadstone, and so moving regularly in any posture.

2. Burning coals in a box dissolved by air, as a menstruum, in the opinion of Mr. Hooke.

3. A microscopical observation of moss seeds.

4. A representation of the manner, how the planets may move from a natural cause in an ellipse by Mr. Hooke, who was ordered to prosecute the experiment.

Pendulums and Lens Engine.

He was ordered likewise, to prepare against the next meeting the long pendulums with great weights formerly appointed, to try how long they would go even together; as also one of the two new engines for grinding elliptical and hyperbolical glasses.

Parallax.

July 6. Hooke's first observation of γ Draconis to prove parallax.

Hand of Sea-leopard.

July 8. Mr. Hooke acquainted the society, that looking over some of the things in their repository, he had met with such a hand as Monsieur le Febure once produced before the society, mentioning, that it was given him for the hand of a mermaid; but that this hand was a part of a sea-leopard, and altogether like that of Monsieur le Febure.

Torsion.

Mr. Hooke proposed an experiment about the strength of twisted cords, compared with untwisted ones, to be tried at the next meeting, together with those others, that should have been made at this meeting.

Parallax.

July 9. Second observation of γ Draconis.

Torsion.

July 15. Mr. Hooke made an experiment of comparing together the strength of twisted and untwisted silk, and it appeared by the several trials made of it, that a certain number of threads untwisted proved stronger than so many twisted. Whence Mr. Hooke concluded, that cables made faggot-wise would be stronger than when twisted.

To this it was objected, that cables would not then be so manageable; and that certainly people had not been wanting to make trials of this nature, but had doubtless found, that, all things compared, the inconvenience would prove greater in the use of untwisted than twisted threads.

Mr. Hooke remarked upon this, that the belief of the superior

strength of twisted threads to that of untwisted had doubtless proceeded from trials made upon flax, which having but short pieces held not therefore so well untwisted as twisted.

Reflecting Instrument.

There was produced the instrument of taking an angle between two objects, so as to see one of them immediately by the eye, the other by reflection.

New Watch.

Mr. HOOKE promised to have ready at that meeting one of his new kind of watches, that should go fourteen months, which he first produced and described May 6, 1669.

Parallax.

Mr. HOOKE intimated, that he was observing in Gresham College the parallax of the earth's orb, and hoped to give a good account of it.

Experiments to order.

July 22. It was ordered, that Mr. HOOKE should, during this interval, make such experiments in private, as were in the former meetings committed to his care and left hitherto unperformed. As also, that such others of the society, who had conveniency to make any observations and experiments of a philosophical nature, should be desired to be mindful of doing what they could during this recess of the society against the resuming of their meetings.

Parallax.

Aug. 6. Third observation of γ Draconis.

Oct. 21. Fourth observation of γ Draconis. Results published in 1674.

In MS. *Bradley* 20* is the following record of Dr. Hook's Observations of γ Draconis.[1]

1669.	Jul.	6th	2′ 12″ No.
		9th	2′ 12″ No.
	Aug.	6	2′ 6″
	Octob. 21	1	48″ or 50″ N.

N.B. According to my Observation the star would have been $5\frac{1}{2}''$ more northerly Oct. 21 than twas July ye 7th or 8th, whereas Dr. Hook makes it 23″ more southerly. Diff. = $27\frac{1}{2}''$. And by my observation twas 2″ more southerly on Oct. 21 than on

[1] Obviously extracted from Hooke's *Movement of the Earth* 1674.

August 6th, whereas Dr. Hook makes it then 17″ more southerly, that is 15″ Difference from mine.

Dyeing.

Oct. 21. Mr. Hooke produced a piece of stuff stained by a way of his own contrivance, which he said he hoped to perfect, and to make it serve for staining whole suits of hangings. He was desired to pursue this experiment.

Willisel's plants.

It was ordered, that Dr. Merret be thanked for digesting the plants collected by Thomas Willisel, and that Mr. Hooke take the whole collection into his custody for the repository, making first of all an inventory of them, and producing them before the society.

Measure of a Degree.

The Lord Bishop of Chester acquainted the society, that His Majesty had expressed a desire of having the measure of a degree upon the earth determined, and expected the assistance of the society in it:

Upon which it was ordered, that the Bishops of Salisbury and Chester, Sir Robert Moray, Sir Paul Neile, Dr. Wallis, Dr. Christopher Wren, Dr. Goddard, and Mr. Hooke, or any three or more of them, be a committee to consider of a way of determining the measure of a degree upon the earth; and that they meet for that purpose at the President's house in Covent Garden on the Monday following about five in the evening, and make a report to the society, when they shall have concluded anything in this matter.

Mr. Hooke was likewise desired to peruse what Riccioli had written and performed on this subject, and to give an account thereof to the said committee at their first meeting.

Pendulum Clock.

Oct. 28. Mr. Hooke produced a new kind of pendulum-clock, designed to keep time more exactly than others, for astronomical observations, and so contrived, that the swing being in this clock fourteen feet long, and having a weight of three pounds hanging to it, was moved by a very small force, as that of a pocket-watch, the swing making its whole vibration not above a degree, and going seventy weeks.

It being objected, that any concussion was likely to disorder or stop it, Mr. Hooke declared his opinion, that it would not. He was ordered to try it in astronomical observations, and give the society an account of its success.

Dyeing.

He showed again a piece of stained flannel, as being thought the most difficult stuff to be stained; and he again expressed his hopes of staining whole pieces of hangings after this manner, even in vivid colours.

Saturn's Belt.

Mr. HOOKE affirmed, that such a belt about the middle of Saturn had been observed in England by Mr. BALLE about three years ago; and that he had a letter of that gentleman mentioning it.

Engine for Elliptical Grinding.

It being observed, that it had been ordered above three months before, that Dr. WREN'S engine for grinding hyperbolical glasses, and that of Mr. HOOKE for elliptical ones, should be prepared for making trials of them; and it being found, that neither of them were prepared; the order was renewed to Mr. HOOKE for doing it with all convenient speed.

Measure of a Degree.

The order of the last meeting, appointing a committee for considering of a way to determine the quantity of a degree upon the earth, being renewed, and those members, who might since have had thoughts of it, being desired to speak of it, Mr. HOOKE declared his opinion, that one of the exactest ways of performing it might be by making accurate observations of the heavens to a second by a perpendicular tube, and then to take exact distances of angles to a second also.

Nov. 4. Mr. HOOKE proposed a way of dividing a degree in very many minute parts, which he conceived to be much more easy than that by a screw or a sliding ruler, or any other known to him. It consisted in proportioning a short line, which is to be divided into many small parts, to a long line. This being examined, and the application of it to practice for taking measures both in the heavens and upon the earth debated, it was thought proper to be used in the experiment of measuring a degree upon the earth, recommended by His Majesty to the consideration of the society: and Mr. HOOKE was ordered to make the apparatus necessary for that work ready with all possible speed.

Calico Dyeing.

Nov. 11. Mr. HOOKE produced a piece of calico stained after the way contrived by himself, which he was desired to prosecute in other colours besides those, that appeared in this piece.

Seed of Ferns.

He produced likewise several capillary plants, supposed to have no seed, on which however he found little cases or boxes, which being opened and put into a good microscope were found to have seed.

Refractometer.

Nov. 18. Mr. HOOKE produced an instrument of his own contrivance to measure the quantity of refractions; and the experiments made therein were ordered to be repeated at the next meeting.

Density.

Mr. HOOKE promised for the next meeting some experiments of weighing bodies, to show the porosity of them, and a way of making them more compact than they were before by hammering them.

Nov. 24. FLAMSTEED wrote to Lord BROUNCKER. 'For Telescopes, if we may credit the modest boasts of our mechanical artists, the world affords no better than the English possess: which yet the thrice ingenuous Mr. HOOKE persuades us may be promoted to a greater perfection. I cannot but acknowledge that this acute author hath done his country singular service by his Micrographia, and describing the engine for grinding glasses;[1] it is only desired that he had acquainted us what sands and powders to use for the wearing and polishing of them. He affirms to know several secrets for the meliorating and improving of optics, of which yet we have had no treatise that I know of, published either by Englishmen, or in the English tongue. He may do well to accommodate his country, which expects it from him, with something of them and the dioptrics in her vernacular tongue, and to afford her what he professes to know, and yet conceals, of such optical inventions. Why burns this lamp in secret?

> Quo didicisse —— nisi quod semel intus
> Innatum est, rupto jecore exierit? Pers. Sat.

And,

> Quid te scire prodest, nisi te scire hoc sciat alter?

[Rigaud *Correspondence*, p. 83.]

Measuring Angles.

Nov. 25. Mr. HOOKE brought in the instrument for taking angles upon the earth in order to measure a degree exactly, contrived so, that in the use of it no notice is taken of any inequality of the ground; the wire employed therein being always equally extended by an equal weight.

[1] Phil. Trans., Vol. I, p. 63.

Etching.

Dec. 2. Mr. HOOKE produced a picture printed after the expeditious manner of Dr. WREN, who having covered a very thin brass plate with etching varnish, caused it to be etched upon by a hand careful not to close any letter, in which work the aqua-fortis must be so strong, as to corrode the plate quite through: Which done, the plate is to be turned and laid upon another thick plate covered all over with printer's ink, to be passed, after the usual manner, through the rolling-press.

Mr. HOOKE was desired to prosecute and perfect this invention of Dr. WREN.

Dividing Engine.

He brought in the instrument, formerly promised by him, for dividing a degree into as many small parts, as may be desired, not by a screw or a sliding ruler, but by proportioning a short line to a long one, in order to measure the distances of the stars, and the diameters of the planets. This instrument was to be applied to a twelve-foot telescope, and represent a degree in two inches, and magnify thirty times, observing even to seconds; and to be employed in the experiment of measuring the quantity of a degree upon the earth, by measuring therewith, how far a star passeth from the zenith; which is done by making two observations, the one northward, the other southward, and taking notice, by the advantage of this contrivance, of the distance, and thence concluding the quantity of a degree, or part of a degree.

Dyeing.

Dec. 9. Mr. HOOKE produced another specimen of staining with yellow, red, green, blue and purple colours; which he said would endure washing with warm water and soap.

Excuse for not providing Experiments.

Mr. HOOKE being called upon for the experiments appointed for this meeting, excused himself for not bringing them in, he having had some avocations of a public nature, which had hindered him from preparing those experiments; which he was ordered to do against the next meeting.

Wren's Etchings.

Dec. 16. Mr. HOOKE exhibited another specimen of Dr. WREN'S new and compendious way of printing; in which pictures likewise might be done.

Muscular Contraction.

Upon reading a paper on muscles, by Dr. GODDARD, it was

suggested by Mr. HOOKE, that it would be worth considering what it is, that by its influx makes the muscles act by contraction; and then how the muscles are again relaxed by nature's discharging that liquor or spirit, which contracted them. To illustrate this, he mentioned, that spirit of wine (for example) poured upon gut-strings contracts and shortens them, and being thence evaporated relaxes and lengthens them again. So that, he said, there must be a very subtile volatile spirit, that enters into the muscles; and the same must very quickly be discharged again to cause the contraction and expansion of the muscles.

He intimated likewise, that if he could communicate the force of gunpowder to a spring, he might then command as much strength as he would.

Rectified Spirit of Wine.

Occasion being here given to speak of well-rectified spirit of wine, Mr. HOOKE said, that it might be yet more refined after that all would burn away, it being possible, that though it will burn away, yet there might still be some phlegm in it, which may be carried up with the volatile spirit. He added, that the best proof of its perfect rectification was, if it would fire gunpowder.

Cloth-making.

Mr. HOOKE was ordered to discourse further with this Mr. SMITH of all the particulars of his new way of cloth-making, and set down in writing the method used by him in executing what he affirmed: As also to get a specimen of what he said had been already performed in his new way; and to offer him his assistance in the contrivance of divers tools, which he should want.

Particular notice being taken of what Mr. SMITH had affirmed, that he could make a hair as fine as silk, Mr. HOOKE remarked, that if this could be done, he could tell how to give them all the glossy colours, that should be desired.

In the meantime Mr. HOOKE was desired to make the experiment of measuring a degree upon the earth; and to get his new clock, designed to go fourteen months, finished; and to prosecute his method of staining, and the new manner of printing.

Library Catalogue.

Dec. 20. Dr. BALLE and Mr. HOOKE were desired to finish the catalogue of the society's library within the approaching holydays.

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Jan. 11. WALLIS in a letter to COLLINS recommends that a copy of HOOKE'S *Micrographia* be sent with other books to BORELLI.

Dyeing.

Jan. 13. Mr. HOOKE brought in two specimens of staining better than those produced by him before.

He intimated, that an acquaintance of his lately gone to Malabar had promised him to endeavour to get the art of staining used by that people, which that person had said to be performed by them chiefly with a root.

He added, that the preparing of the cloth or stuff to be stained was a main thing in this work, to hinder the colours from spreading too far, and from running all along the thread.

Petrifying Springs.

Mr. HOOKE mentioned, that he had been informed of two springs in Northamptonshire, neither of which single would petrify, but meeting together they did so. He was desired to learn more particulars of it.

Universal Measure.

Jan. 20. Mr. HOOKE produced for examination two ways of making an universal measure, one by purged quicksilver, dropped on a plane exactly horizontal, and having a dry surface, until the horizontal diameter of it be double to the perpendicular of the same; which being obtained by exactly comparing the said two lines together, the longer of them shall serve for the measure, e. g. for an inch.

The other way was by dropping distilled water from the point of a very fine needle, and counting so many drops for a measure of such a denomination.

Many exceptions were made by divers of the members against both these ways: to the former, that even distilled mercury would be different; and that the air of several places would alter the dimensions; and that it was very difficult to measure exactly the horizontal and perpendicular diameters. To the latter, that it is very difficult to have everywhere needles equally pointed, as the same size of drops.

For these and the like difficulties both these ways were laid aside.

Engine for Grinding Hyperbolical Lenses.

Mr. HOOKE having declared his opinion, that Dr. WREN'S engine for grinding hyperbolical glasses would not be practicable, as he did not see how rings could be avoided in that way; but

that he conceived, that his own engine, formerly produced before the society for working glasses, both of an elliptical and hyperbolical figure, might be reduced to useful practice, he was exhorted by the society to cause such an engine to be made with all possible speed; to which he answered, that one was making.

Jan. 24. FLAMSTEED in a letter to COLLINS asks for information about the glasses of NEWTON's small telescope, and adds, 'I intend to work some for my own use and am framing such an engine as Mr. HOOKE describes for the grinding and polishing of them'.

Mechanical Muscle.

Feb. 3. Mr. HOOKE produced a contrivance of his to try, whether a mechanical muscle could be made by art, performing without labour the same office, which a natural muscle doth in animals. It was so contrived, as that by the application of heat to a body filled with air for dilatation, and by the application of cold to the same body for contraction, there might follow a muscular motion. It was objected, that it did not appear, how this agent, that was to produce heat and cold, could be applied for use, so as to cause this motion immediately, and with that speed, as it is done in animals. However Mr. HOOKE was ordered to consider more fully of it, and to acquaint the society with the result of his further considerations.

He suggested, that if it could be done leisurely this way, the motion might be rendered quick by springs.

Entertainment in Hooke's absence.

Feb. 10. Mr. HOOKE being absent, the society, instead of experiments, was entertained with the reading of some letters.

Respiration.

Feb. 24. Mr. HOOKE reported, that the anatomical experiment concerning the use of the lungs, which he had promised to make in private, had not succeeded, but that he intended to try it again betwixt that and the next meeting.

He showed an experiment to illustrate, how the figures of trees, that are naturally made upon divers stones, may be formed by art; which he did by rubbing two polished marbles together, between which there was put some water, so that after they had been a little while rubbed together, and were thereupon so drawn; as that some air might intermix and dilate the water, there appeared plain figures of the form of trees. Whence it was conjectured, that the like figures, formed by nature upon sundry stones, might be made by some water oozing through stones, and working upon them, air being intermixed and dilating the liquor.

Occultation of two Stars.

Mar. 3. Mr. JEFFREYS gave some account of the two stellar eclipses lately observed by him and Mr. HOOKE; which he was desired to bring in writing at the next meeting.

Pendulum in vacuo.

Mar. 24. Mr. HOOKE being called upon for the experiment of moving a pendulum in an exhausted receiver said, that Mr. BOYLE, since the last meeting, had told him, that there was no sensible difference between the celerity of a pendulum's motion in the air and that *in vacuo*. However it was ordered, that this experiment should be made before the society at their next meeting.

Occultation of Stars.

Mr. HOOKE made a report of the observations made by himself and Mr. JEFFREYS of two late stellar eclipses predicted by Mr. FLAMSTEED, which happened February 25 and March 3, 1669/70; concerning which he said, that in the former they could not see the sub-ingress, but saw the egress, the time of which agreed very near with that assigned by Mr. FLAMSTEED: And that in the latter they observed the time of the sub-ingress 17 h. 2 m. which differed considerably from the time calculated by Mr. FLAMSTEED: And they added, that they expected the egress till 18 h. 45 m.; but that the day then clearing up, and the smoke and vapours ascending, they lost the sight, which they had, of the moon. These observations were made with a six-foot telescope.

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Eclipse of Sun.

Apr. 7. It was ordered, that Mr. FLAMSTEED be requested by Mr. OLDENBURG to proceed in making his calculations; and to inform him, that Mr. HOOKE would undertake to make the observations.

Mr. HOOKE was desired to find out a place to make his observations of the sun and stars by a new way, which he then proposed.

True Meridian.

Apr. 14. [Auzout's observation on the declination of the magnetic needle] being agreeable to what was asserted by Mr. HENRY BOND, whose hypothesis of the motion of the magnet led him to affirm, that this year the variation at London would be 2° 18′, it was ordered, that Mr. HOOKE should direct an easy

and sure way to describe an exact meridian; and that then observations should be made, to see how far they verified Mr. BOND's hypothesis.

Mr. HOOKE suggested a method for striking exact meridians by the North star, and by observing the time of the night.

Solar Instrument.

Apr. 21. Mr. HOOKE brought in his instrument to observe the motion of the sun to seconds; which was ordered to be produced again at the next meeting, and to be tried upon the leads of Arundel House, if the sun should shine.

Hypothesis of Tides.

Mr. OLDENBURG read Mr. HYRNE's hypothesis of the flux and reflux of the sea opposed to that of Dr. WALLIS, the author asserting himself to be as fully satisfied concerning the cause of this phenomenon, as of anything in nature.

Mr. HOOKE intimated, that he had another hypothesis concerning the tides different both from that of Dr. WALLIS and that of Mr. HYRNE, which, when he had perfected it, he would communicate to the society.

Cloudiness.

He was desired to give in writing a description of the experiment made by him at the last meeting, representing the serenity and cloudiness of the air by the successive infusion of two different liquors into a solution of copper; which he promised to do.

Memoranda.

Mr. HOOKE was put in mind of observing the declination of the needle, of prosecuting the experiments of the motion of pendulums in the air and the exhausted receiver, and of the motion of the blood in animals out of the veins into the arteries without the concurrence of the lungs.

Salary.

Apr. 27. It was ordered, that the Treasurer continue to pay to Mr. HOOKE his salary of thirty pounds a year from the time of his last payment, which was appointed to be made to him by an order of the council of Feb. 1, 1668/9.

Solar Instrument.

Apr. 28. It was ordered, that the instrument contrived by Mr. HOOKE for observing the motion of the sun be produced again at the next meeting.

Parallax.

He exhibited his contrivance of the glass tube posited perpendicularly, for observing the stars in the zenith, to try to find the parallax of the earth's orb, in order to determine the question of the earth's motion. He was solicited to carry on these observations with care and diligence.

Solar Instrument.

May 5. Mr. HOOKE brought in his instrument for observing the motion of the sun to seconds; and the experiment being made but imperfectly, it was ordered, that the said instrument should be fitted against the next meeting with a ball and socket to keep it steady.

Wren's Winding Contrivance.

Dr. CHRISTOPHER WREN produced a new contrivance of his for a more convenient winding up of weights by ropes, and serving for wells, mines and cranes, and thought applicable to clocks.

This being thought applicable to clocks, Mr. HOOKE was ordered to make a trial of it.

Air-gun.

May 19. Mr. HOOKE produced an engine, that may serve for a wind-gun, and be more easily charged than an ordinary one, and yet shoot as certainly as that. But the valve being yet wanting, it was ordered, that it should be made ready against the next meeting.

Magnetic Variation.

It was also ordered, that the variation of the needle should be observed by Sir ROBERT MORAY and Mr. HOOKE at Whitehall on the 1st of June following.

Ball and Socket for Solar Instrument.

Mr. HOOKE was put in mind to get a ball and socket made against the next meeting for the instrument of representing the sun's motion to a second.

Weather-clock.

It was ordered, that a weather-clock should be bespoken by Mr. HOOKE, such a one, as Dr. WREN had formerly contrived, for observing not only the winds and their quarters and degrees of strength, but also the quantities of rain, and other particulars relating to the temperature of the air.

Occultation of Antares.

May 23. Hooke observed this occultation. See below, March 20, 1670/1.

Camera obscura.

May 26. Mr. Hooke produced an optical experiment, whereby the representation of objects in a dark room furnished with a lens is made applicable to painting, so as to exhibit and draw in colours the face of a man or any other object as big as the life.

It was ordered, that against the next meeting something should be designed, and, if it could be, painted, by the means of this instrument.

It was suggested, that whereas the pictures represented in the darkened box are inverted, they might be reverted by the reflection of a flat piece of metal; though others were of opinion, that this would alter the colours of the objects represented.

Magnetic Variation.

Sir Robert Moray was reminded to make an observation of the variation of the needle together with Mr. Hooke.

Camera obscura.

June 9. The dark box for painting all sorts of objects was produced again with some improvements, which were chiefly two, viz. the changing it into a convenient posture for drawing, and the representing the figures direct: but the latter being done only by a looking-glass, which takes off much of the brightness of the picture, Mr. Hooke thought, that a metalline plate well polished would do much better; and he was ordered to try to make a picture that way at the next meeting.

Magnetic Variation.

It was ordered also, that Sir Robert Moray and Mr. Hooke should meet at Whitehall the night following, in order to observe the present variation of the needle; and that the latter prepare things necessary for that observation.

Measurement of a Degree.

Mr. Hooke was ordered likewise to make ready for measuring a degree upon the earth in the next vacation. The place to do it in was appointed to be Bedford River about twenty miles in length, formerly surveyed with exactness by Mr. Moore.

Meridian.

June 23. Sir Robert Moray and Mr. Hooke made a report, that on the 13th instant they had made an observation to find,

whether there was now a difference of the present meridian from that, which was formerly made on the dial in Whitehall garden. They made their observation by the North star in this manner. At 10 h. wanting 4 minutes they began to observe; the said star being to be just east at 1 h. $\frac{1}{4}$: they hung on poles perpendicular threads, which covered one another and the star, and the south-east side of the said dial. The breadth of the dial's upper edge to the opposite was 4 feet $4\frac{1}{2}$ inches, and the plane between the two perpendicular threads was distant from the north-east edge of the dial 3 inches wanting $\frac{1}{20}$ part, which gives the angle of the pole's distance eastward from the meridian of the dial. Here the breadth of the dial gives the radius, and the distance of the plane between the two perpendiculars gives the tangent. Then the difference between the distance of the star from the pole, and the distance of the plane between the perpendiculars from the side of the dial, gives the distance of the dial from the meridian, if any there be.

Assistant for Hooke.

June 28. It was ordered, that Mr. HOOKE do find out a man fit to be employed by him in the service of the society, and that such a one have allowed him five pounds for a quarter of a year, to begin from the time, that Mr. HOOKE shall declare to the President, that he had taken such a one into his service.

It was agreed, that a curator, if a fit one could be met with, be entertained by the society for a quarter of a year, to begin from the Michaelmas following.

Camera obscura.

July 7. Mr. HOOKE produced again his darkened box improved, so that it was now proper for the hand to draw a picture conveniently by a metalline speculum and a movable bottom, whereby the picture appeared both erect and direct.

Cloudiness.

July 14. An account of the experiments for explicating the thickening of the air by clouds and fogs, and the clearing of it in fair weather; by Mr. HOOKE, which account was as follows:[1]

There was made a solution of verdigris in clear water, which was afterwards filtered through cap paper, so as to separate all such dregs and parts of the verdigris, as were not perfectly dissolved. Of this solution about a pint was put into a clear glass cone, which being looked through, represented the colour of a clear blue sky, and was yet further heightened in that colour by a drop or two of spirit of sal ammoniac or of urine. To make

[1] Cf. R. S. MS. No. 49.

then a representation of the thickening of the air, some few drops of oil of tartar *per deliquium* were dropped into it, and shaked together; whereupon, all the said liquor did become thick and turbid like a foggy or misty air. If it were dropped in very leisurely, and a little of it, it would appear like many little white clouds, dispersed up and down the air: if, after the liquor was thick and turbid, a little oil of vitriol or aqua-fortis were poured gently into it and suffered to fall to the bottom of the vessel, the liquor would begin to clear at the bottom, and the thicker and whiter parts to hang towards the top like white clouds in summer, which being suffered to stand for a while, or if the liquors so mingled were shaken together, the whole liquor would become clear and transparent almost as water; and might again be reduced to exhibit all the former phenomena, if a greater quantity of the aforesaid liquors were again poured into it.

Meridian.

July 21. Mr. HOOKE was put in mind to prosecute the observation of the meridian at Whitehall, together with Sir ROBERT MORAY.

The experiments of weighing copper and silver were referred to the next meeting; as also the examination of Mr. HOOKE's instrument for taking angles.

Reflecting Instrument.

July 28. There was examined an instrument invented by Mr. HOOKE for measuring the distances of celestial bodies by taking angles, conceived to be of great use at night. It was so contrived, that two objects meeting at the point of a pin were seen at once, one direct, upon one arm of the instrument furnished with a telescope, the other by reflection, on the other arm, sliding upon a ruler, divided into equal parts.

It was ordered, that an instrument of this kind be made to be sent to sea.

Magnetic Variation.

Sir ROBERT MORAY and Mr. HOOKE were desired to observe the present variation of the needle in Whitehall garden, during the discontinuance of the society's meetings.

Parallax.

Mr. HOOKE reported to the society, that he had already found so much, as to suspect some parallax of the earth's orb, and conceived, that it would be more sensible half a year after. He said, that by a perpendicular tube he observed the stars,

which pass our zenith, at different times of the year, and by noting, whether the same star be at those different times of observation at the same distance from the zenith or not; concerning which he affirmed, that a certain star was then less distant from the zenith than it had been a month before.

He was desired to prosecute carefully this observation, so important to determine the controversy concerning the motion of the earth.

Work for the Summer Vacation.

The society thinking proper to discontinue their public weekly meetings, there was recommended to Mr. HOOKE during this recess the care of these three things: 1. To continue to observe, whether there be a parallax in the earth's orb. 2. To observe the present variation of the needle. 3. To measure the precise quantity of a degree upon the earth.

Eclipse of Moon and Telescope Construction.

Sept. 19. FLAMSTEED wrote from Derby to COLLINS concerning the Eclipse of the Moon on Sept. 18. 'I wrote to Mr. HOOKE about the observing this eclipse. . . . If he did, and the heavens smiled on his endeavours, desire him to be pleased to communicate his observations to me; for I think the heavens anteverted our calculations some minutes, which, if so, favours an equation I have long since conceived ought to be induced into the lunar system. I could wish he would be pleased in a line or two, at his leisure, to inform me at what distance my glasses may be placed in the tube . . .; and likewise how I may most conveniently hang it for observations, for I saw none hung when I was at London; and likewise at what distance the brass instrument which Mr. MOORE bestowed on me may be placed from the eyeglass. . . . I am much and sensibly obliged to yourself and Mr. HOOKE in procuring me my glasses at so easy a rate, when, had I bought them myself, they would have cost me double and above.'

Oct. 1. 'I have not yet got a tube to my glasses: I wait till I may hear from you how Mr. HOOKE approves of them, and at what distance they are to be placed.'

[Rigaud, *Correspondence*, pp. 99, 101.]

Iceland Spar.

Oct. 27. Mr. HOOKE was desired to give an account of Iceland spar at the next meeting.

Watch.

Mr. HOOKE promised to produce at the next meeting a new watch-work, which should be equivalent to a pendulum.

Measure of a Degree.

He was put in mind to finish at last the mensuration of the quantity of a degree upon the earth; and he promised, that in the first frost and clear weather he would observe the latitudes of the places in reference to that business.

Watch.

Nov. 10. Mr. HOOKE produced an essay of a new watch-work, which he said might be made into a pocket-watch, and would go equally in all positions and motions at sea: Which he was desired to perfect, if he could, against the next meeting.

Book on Motion.

Mr. HOOKE mentioned a little book lately translated into English out of French, and printed at London 1670 in 12° under the title of *A Discourse about local Motion*, undertaking to demonstrate the rules of motion, and to prove, that of the seven rules given by DESCARTES on that subject, there is but one true. He intimated, that he intended to make some experiments in order to try the truth of the author's observations, and to show them to the society.

Hooke Censured.

Nov. 14. It was resolved, that Mr. HOOKE be summoned to attend the next meeting of the council, to receive their rebuke for the neglect of his office.

Watch Work.

Nov. 17. Mr. HOOKE produced another watch-work performing the effect of a pendulum; but he acknowledged it not so valuable as what he had showed at the last meeting; which therefore he was desired to prosecute and perfect.

Glass broken by Sound.

Mr. HOOKE being asked, whether he had tried the experiment of breaking a glass with a human voice, said, that he had tried it, but found no other success, than that the glass had sounded upon the sound of a man's voice.

He was desired to try it again, and to take care of finding the tone of an octave requisite for the effect; and that being found, to continue it for a while forcibly and without interruption.

Nov. 24. Mr. HOOKE being absent from this meeting, no experiments were provided.

Flamsteed's Telescope.

Dec. 1. FLAMSTEED wrote to COLLINS that he had not heard from Mr. HOOKE. 'I intend now', he says, 'to make trial myself,

for I would not trouble him further in that business, who, I perceive, is full of employment.'

Mechanics of Arch.

Dec. 8. Mr. HOOKE brought in this problem of architecture: The basis of the distance of two pillars and the altitude of an arch being given, to find out the right figure of that arch, for the firm sustaining, upon the whole, or any part of it, any weight given; as also to find out the butments of that arch.

Mr. HOOKE being asked, whether he had the demonstration of this useful problem, he said he had it, and would show it to the President.

He was desired to represent at the next meeting the mechanical way of making such an arch by pieces of angles standing in such angles, as to make the figure of an arch required; which he promised to do.

Falling Bodies.

Mr. HOOKE was ordered to prepare for an experiment to be made at the next meeting in the assembly room, by having two balls, and projecting the one horizontally from the window over the door, and letting the other fall down perpendicularly from the same height.

Mechanics of Arch.

Dec. 15. Mr. HOOKE represented the mechanical way of making an arch of such a figure, as shall sustain any weight given. Being asked, whether he had ready the demonstration of it, he answered, that he had given it to the President, who was absent from this meeting.

The experiment of the horizontal projection and perpendicular fall of bodies was referred to the next meeting.

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Chatham Hippopotamus.

Jan. 12. Mr. HOOKE brought in a curiosity, sent to the society for the repository by the Archbishop of CANTERBURY, supposed to be several pieces of an hippopotamus, digged up at Chatham, according to a printed paper accompanying the same.

Pressure of Water.

Sir ROBERT MORAY mentioned, that the King had laid a wager of fifty pounds to five for the compression of air by water; and that it was acknowledged, that His Majesty had won the wager. Sir ROBERT desired, that the experiments formerly made for

evincing this fact might be made before the society, and afterwards before the King; which he said might be done by a cane contrived after such a manner, that it should take in more and more water, according as it should be sunk deeper and deeper into it.

He desired likewise, that the experiment of supporting any heavy body at a certain depth under water, by keeping it from being depressed by any incumbent water, might be made.

It was ordered, that the apparatus for the first of these experiments should be made ready by Mr. HOOKE for the next meeting.

Grinding Engine.

Mr. HOOKE produced his engine formerly promised for grinding glasses of a true both elliptical and hyperbolical figure; whereby, he affirmed, all the motions made by this contrivance touch every point in an ellipse.

It was ordered, that this engine should be put in a frame, and a trial made of its performance. Some of the members doubted, that this engine would wear, and the sand remain uneven, which would make the figure of the glass imperfect. But Mr. HOOKE was of opinion, that by this engine the sand would be prepared equally fine, and so spread everywhere.

Large vessel for rarified Air.

He proposed a new way of making a vessel for extracting the air, so large, that a man might sit in it, and so contrived, as to rarefy the air to a certain degree, and to supply the person sitting in it with fresh air. He was desired to get such a vessel made.

Mechanics of Arch.

The demonstration of Mr. HOOKE concerning the line of an arch for supporting any weight assigned, being called for, Mr. OLDENBURG mentioned, that Dr. WREN had also a demonstration of it. It was desired, that these demonstrations might be both delivered and opened together by the President.

Falling Bodies.

Jan. 19. The other experiment about the synchronism of the fall of a projected and a perpendicularly descending body was referred to the next meeting, and the operator ordered to speak for the key of the room over the door of the meeting-rooms to make the experiment in.

Compression of Air.

Mr. HOOKE was called upon to make ready the apparatus necessary to show the King the compression of air by water; which

he promised to do. It was desired, that the same experiment might be made in a bottle, wherein the air should be so compressed, as to drive out the water. Both methods were directed to be first represented to the society.

Air vessel and grinding Engine.

Mr. HOOKE promised likewise, that at the next meeting he would bring in the new air vessel; as also, if he possibly could, the new glass-grinding engine.

Mechanics of Arch.

Mr. HOOKE being called upon for his demonstration of the [line for an arch] answered, that he had already declared the substance of it to the President, who yet desired him to give it also in writing, that so it might be with more leisure and conveniency examined.

Succedaneum of Tea.

Mr. HOOKE produced from Mr. TOWNLEY a box full of a certain herb pretended to be a succedaneum of tea, and said to grow plentifully in Lancashire. Some of the members viewing it found it to be the *Myrtus Brabantica*, in English, Sweet Willow.

Compression of Air.

Jan. 26. An experiment was made of compressing air by water, which was done in a large tube of six feet long, filled with water, and by letting into it a syringe open at one end, in which the air was at the depth of two feet and a half compressed about one inch, and at the depth of five feet near two inches.

Falling Bodies.

There was also made the experiment to find, whether a ball horizontally projected, and another falling down perpendicularly, would come to the ground at the same time from the same height. This was done by blowing a small leaden bullet through a hollowed wooden cane, at the orifice of which there was a contrivance made for another leaden bullet of the same figure and size, to fall down straight; which being tried several times, the balls were judged by the ear of some of the members to come to the ground at the same time, by others not. For which reason it was thought necessary to make more trials at the next meeting.

Large Air Vessel.

Feb. 9. Mr. HOOKE being asked, whether the air vessel for a man to sit in was yet ready, answered, that it was, and that he now intended to make some experiments in it, and to report them at the next meeting. He added, that the chief design of

this vessel was to find what change the rarefaction of the air would produce in man, as to respiration, heat, &c. Being asked, how it was contrived, he said, that it consisted of two tuns, one included in the other; the one to hold a man, the other filled with water to cover the former, thereby to keep it staunch; with tops to put on with cement; or to take off; one of them having a gauge, to see to what degree the air is rarefied; as also a cock to be turned by the person, who sits in the vessel, according as occasion shall require, &c.

It was resolved, that after a report shall be made by Mr. HOOKE of the success of the experiments to be made by him this week, a day be appointed for as many of the society, as pleased, to meet in Gresham College, to see the vessel and some experiments to be made therein.

Motion of Sap in Trees and their Pores.

[Mr. MARTIN LISTER'S letter concerning the bleeding of sycamores] gave occasion of much discourse concerning the motion of sap in trees, and of the texture of them.

Mr. HOOKE said, that he had observed, that there were several sorts of pores in trees; some of them went from the middle to the bark, shaped like little desks or boxes; others were like pipes going from the top to the bottom of the tree; others were exceedingly small, not seen but by a microscope, which he therefore called microscopical pores.

Others moved, that it might be further inquired into, whether there be a circulation of the sap in trees? Dr. GODDARD said, that a straight ligature having been made about a vine-tree, there had been observed a turgescence as well above as beneath the ligature.

Mr. HOOKE proposed a contrivance to find with some certainty, whether there be a circulation in trees; which contrivance he was ordered to get made against the next meeting; which he promised to do.

Grinding Engine.

Mr. HOOKE being put in mind of his engine for grinding glasses said, that he would get the whole apparatus ready, as soon as he could.

Sap in Trees.

Feb. 16. Mr. HOOKE produced a model of a little box to be thrust into the body of a tree bored, to find out the ascent and descent of the sap. The care of making this experiment was committed to Mr. CHARLES HOWARD, who promised to undertake it.

Colour Printing.

Mr. Hooke produced likewise a picture done by himself upon taffeta after an unusual way, viz. by printing it, and then giving it the colours, which appear equally well on both sides, being varnished over and transparent. He said he had the varnish from Mr. Wylde.

Large Air Vessel.

Feb. 23. Mr. Hooke reported concerning the air vessel, that he had been in it for about a quarter of an hour, and found not any inconvenience upon the exhaustion of the little air drawn out of it. He added, that he conceived, that a man could not endure much more than the evacuation of a fourth part of the air contained in this vessel.

He was ordered to prosecute this experiment, and to take some animals and lighted candles &c. with him into the vessel.

It was also resolved, that on the Monday following in the afternoon as many of the society as pleased should meet in Gresham College at Mr. Hooke's lodgings, and be present at the experiment.

Mr. Hooke mentioned, that he intended to employ a pair of bellows in the vessel, in order to blow out the air more readily and more effectually.

Mar. 2. Mr. Hooke made a report of the success of the experiment made in the vessel for rarefying the air, viz. that himself had been in it, and by the contrivance of bellows and valves blown out of it one-tenth part of the air (which he found by a gauge suspended within the vessel) and had felt no other inconvenience but that of some pain in his ears at the breaking out of the air included in them, and the like pain upon the readmission of the air pressing the ear inwards.

It was ordered, that this vessel should be in readiness to make the experiment for those of the society, who should be at leisure to go to Gresham College, and be present at it on the Monday following in the afternoon.

Experiments for Florentine Visitors.

Mr. Oldenburg mentioned, that there were come to London two noble Florentines, the Marquis Bartholomei and Count Bardi, who were desirous of being present at a meeting of the society, and of seeing some experiments; and that they would come to the next meeting: on which account Mr. Hooke was appointed to prepare some experiments against that meeting for their entertainment.

Experiment of Flour in Vibrating Glass.

Mar. 9. There were present at this meeting the Marquis Bartholomei and Count Bardi, as also the resident of Venice; and the following experiments were made: 1. One furnished by Mr. Boyle of water falling in an exhausted tube to the bottom like a metallic body, there not being air to break the fall. 2. One contrived by Mr. Hooke, whereby some flour put in a wide shallow glass, with a large sloping brim and a pretty tall foot, was made to rise and run over like a fluid, by the knocking of the glass, and by the forcible moving of one's finger round about the upper edge of the same. Leaden bullets likewise being put in this glass moved in it like a fluid upon its being knocked.

This was proposed, in order to consider, what might be the cause of this motion, especially of the phenomenon, that the flour ascending ran over, and did not fall any way back into the vessel. Mr. Hooke mentioned, that he thought, that it might contribute to explain the cause of gravity, and suggest an hypothesis for explaining the motion of gravity by.

It was ordered, that vessels of different metal should be prepared for the making of this experiment, especially of brass, to strike the more forcibly.

Large Air Vessel.

The air vessel being again spoken of, it was ordered, that since Mr. Hooke had failed in making the experiment at the time before appointed, it should be made on the Monday following in the afternoon, several members promising to be present.

Occultation of Stars.

Mr. Hooke observed, that he had lately observed 4 Mar. the congress of the moon with the *media trium in cauda Arietis*, a fixed star of the third magnitude, and had found the time of its sub-ingress pretty near to that calculated by Mr. Flamsteed, who set down the time to be 10 h. 14′ 52″ which was found to be 10 h. 12′ *circiter*.

Mr. Hooke remarked likewise, that he had observed, that whereas a star, as soon as it touches, uses to disappear, this star touching the south part of the moon slid all along the sides of the edge of the moon, which he thought could proceed from nothing but the refractive air about the moon.

March 20. Flamsteed wrote to Collins, 'I desire you procure me Mr. Hooke's observation, if he made any of the occultation of Antares on Maii 23, 1670.' [Rigaud, *Correspondence*, p. 110.]

Large Air Vessel.

Mar. 23. Mr. Hooke brought in a report of the experiment,

which he had again made in the air vessel; which was, that he had blown out one-fourth of the air that was in the vessel, estimated by a gauge; and that he had continued in it somewhat above a quarter of an hour without any other inconvenience than feeling some pain in his ears, and finding himself deaf, whilst the straining of the air was upon him in blowing out the air; which pain and deafness he likewise found upon the forcible rushing in again of the air into his ears: but that when he was come out, and had walked a little while up and down, his hearing returned. He added, that having taken a candle burning with him into this vessel, the candle went out long before he felt any of that inconvenience in his ears.

The President, who had been at this experiment, remarked, that though Mr. HOOKE had continued somewhat above a quarter of an hour in this engine, yet a quarter of the air in the vessel had not been kept out all that while, but that now and then fresh air had been let in. In the meantime Mr. HOOKE had endured for a little while the absence of a quarter of the air without any other inconvenience than the above mentioned.

Flour moving like a Liquid.

Mr. HOOKE exhibited again the experiment of making flour move in a bell-glass like a fluid several ways, upon the knocking of that vessel in several places; upon which he thought considerable things in philosophy depended, but declared no particulars.

Burning Mirror.

He also showed a method of making a very great burning concave by means of several pieces of glass lined with a mixture of mercury and lead, and put together upon the concave side of some hemispherical body of wood. He was desired to make a trial of it.

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Illustration of the Severn Bore.

Mar. 30. Mr. HOOKE represented by quicksilver in a triangular vessel sharp at one end the reason of the tide's rising so high upon the coast of Bristol and in some other places; which however was thought by some of the members not sufficient to explain the exceedingly high tides upon the coast of Bretagne in France.

Powder in Vibration.

Mr. HOOKE produced his glass-bell with flour in it, to show to the eye, that, according to the several strokes or pulses made

upon the glass, the air thence receives as many several impressions; it being manifest by this experiment, that as every different stroke made a different sound, so the making a different impression upon the flour gave it as many several motions. It appeared also, that the powder goes from the place, whence the pulse comes; and that in a perpendicular pulse the powder hath a kind of vibration: as also, that as long as the sound of the bell lasts, the powder seems to be fluid, but, as soon as that ceases, the powder also lies still.

It being conceived, that this experiment might much contribute to the explication of the nature of the internal motion in bodies, Mr. Hooke was ordered to prosecute it.

Experience in Air Vessel.

He reported concerning the experiment made in the air vessel, that when he was in it, he found not his heart beat quicker, his pulse continuing the same.

Pores of Wood.

Apr. 6. Mr. Hooke mentioned a method, which he had, for discovering the texture of wood by filling all the several pores thereof with mercury, of which he exhibited a specimen in charcoal, promising to show the manner of doing it at the next meeting.

Apr. 20. Mr. Hooke showed the way of filling the several pores in wood with quicksilver, doing it at this time upon a piece of charcoal. He was desired to bring in an account in writing of the manner of doing it; as also of what was discovered by it: and this experiment was ordered to be made at the next meeting upon wood not charred.

He mentioned, that he intended to try the same with fine plaster of Paris, considering, that if it will soak in, it will look white enough, and reflect not so much glaring light as mercury does.

Burning Mirror.

The business of the burning concave being again spoken of, it was thought necessary, that the President, Dr. Wren, and Mr. Hooke should be desired to agree upon the portion of the sphere or parabola, that is sufficient to make all the rays meet in a point; and that Mr. Hooke should bring in at the next meeting a demonstration, showing how many degrees are just necessary to make all rays thus unite.

Mr. Hooke advanced an assertion, importing, that a concave made of a little sphere, reducing all the beams of the sun into a narrow focus, shall burn stronger than a concave made of

a greater sphere, leaving the sunbeams more at large. This he said was demonstrable.

Measure of a Degree.

Apr. 27. Mr. HOOKE being put in mind of performing at least his promise of measuring the quantity of a degree upon the earth, engaged to do it within a month.

Parallax.

He was likewise exhorted to prosecute the observation of the parallax of the earth's orb; concerning which he said, that he thought indeed he should find a parallax, unless it be said, that there may be a variation in the perpendicularity.

Burning Mirror.

He was also called upon to give the demonstration, which he had promised, of the quantity of the sphere, that is sufficient to make all the sunbeams meet for a burning concave: which not having ready, he was desired to bring it in at the next meeting.

Mensuration of the Earth.

It was likewise ordered, that what he had prepared for the mensuration of the earth, as also his apparatus for observing the parallax of the earth's orb, should be by him brought in writing, to be entered in the register-book, in order to secure both from the claims of strangers.

Telescope for Flamsteed.

May 3. FLAMSTEED wrote to COLLINS, 'I must acknowledge myself much obliged to you and Mr. HOOKE for procuring me my glasses. They serve well in a tube of 13½ feet, but cast some colours which will not be easily removed, though I put on a narrow aperture to the object glass.'

Mercury transmitted through Wood.

May 4. There was made an experiment of transmitting mercury through wood, by putting a plug of willow wood at the bottom of a glass cane, and pouring mercury upon it: the success of which was, that the quicksilver made its way through the wood from the smaller end downwards more easily than from the thicker end to the smaller, agreeably to Mr. WILLUGHBY's experiment, who having poured water through branches of birch, holding the great ends upwards, found the water to drop out at the smaller ends; and doing the same through the like branches by holding the smaller ends upwards, found the water to drop out faster through the wood at the larger ends.

This piece of wood being cut, the mercury appeared in all the

parts of it, except the pith and bark, in both which there appeared none at all.

Occultation of Star.

Mr. OLDENBURG desired, that Mr. HOOKE might be put in mind to observe the obscuration of a fixed star, which would happen, according to Mr. FLAMSTEED's pre-advertisement, on the 6th of that month of May.

Mr. HOOKE was accordingly desired to take notice of these particulars, and to join with Dr. POPE in observing them.

Salary.

May 11. It was ordered, that the Treasurer continue to pay to Mr. HOOKE his salary of thirty pounds a year, from the time of his last payment, which was appointed to be made to him by an order of the council of April 27, 1670.

Mercury and Wood.

Mr. HOOKE being called upon for making the experiments appointed at the last meeting, of transmitting mercury through several sorts of wood and through iron, said, that he had made one at home with elder wood, and found no mercury at all in the pith of it. He added, that he conceived the pith to be a congeries of bladders, having no visible communication with the other parts of the wood, as the pith of quills is nothing but a congeries of bladders.

Experiments ordered.

It was ordered, that more of this sort of experiments be made at the next meeting before the society; and that that with iron and quicksilver be not neglected.

Occultation of Star.

Mr. HOOKE gave some account of the observations made by him of the moon obscuring a fixed star of the fourth magnitude, 6 May, 1671, pre-advertised by Mr. FLAMSTEED, viz. that whereas by Mr. FLAMSTEED the time of its ingress had been calculated $9^{\circ}\ 9'\ 57''$ he found it enter about 23 minutes after 9 of the clock; and that its *mora* under the moon was as long as had been calculated, unless there were a difference of a few seconds. He added, that he had made this physical observation, that the star at an equal distance from the light of the moon did not appear above a quarter as big on the light side as on the dark side.

Leibnitz's New Physical Hypothesis.

Mr. HOOKE returned Monsieur LEIBNITZ's *New Physical Hypothesis*, which had been committed at the last meeting to

his perusal, and said, that he was not satisfied with it. Whereupon Sir ROBERT MORAY took it with him to recommend it to the examination of Dr. PELL.

New Star.

[HEVELIUS wrote about a new star circum rostrum Cygni and] this gave occasion to mind Mr. HOOKE to observe this new star in the Swan; as also to observe the present phases of Saturn presumed to appear now with the *ansae.*

Micrometer.

Mr. HOOKE promised to send Mr. HEVELIUS a scheme of the instrument for measuring the diameters of the stars, and taking small distances; as also to send to Mr. FLAMSTEED his late observation of the stellar eclipse of May 6, 1671.

Occultation of Star.

May 18. Mr. FLAMSTEED'S letter to Mr. OLDENBURG, dated at Derby May 13, 1671, was read, giving an account of the stellar eclipse May 6, 1671.

Mr. HOOKE was ordered to communicate his observation of that eclipse to Mr. FLAMSTEED, who earnestly desired it.

Eclipse of Saturn.

May 25. Mr. HOOKE being asked, what observation he had made of the late eclipse of Saturn by the moon, said, that he had missed of that observation.

Leibnitz's Book.

He acquainted the society, that he had perused and considered Monsieur LEIBNITZ'S *Theoria motus abstracti,* but was of opinion, that he had not hit right.

Waywiser.

Mr. HOOKE promised to show at the next meeting an instrument for measuring exactly all the way of a journey, with all the angles thereof.

June 8. Mr. HOOKE produced an instrument for surveying, to be applied to a chariot, whereby what line or angle shall be made by a chariot thus fitted, shall be described upon paper.

He was ordered to get a chariot made, and to apply this instrument to it against the next meeting.

He mentioned, that he had a way to show the several quarters of the world in a travelling chariot, so that wherever a person goes, he shall have a hand standing always north and south. He was desired to produce it before the society.

June 15. The experiment appointed at the last meeting of trying the application of the new surveying instrument to wheels was made with good success: And it was thought, that if the whole apparatus necessary for it be accurate, it would answer the design. Mr. HOOKE was desired to bring in a description of it in writing.

Observatory required.

Mr. HOOKE mentioning, that he wanted conveniencies at Gresham College to make astronomical observations, it was referred to the council to consider of building a turret there for that purpose.

Meridian.

The observation for taking an exact meridian by the North star was again recommended to the President, Sir ROBERT MORAY, and Mr. HOOKE.

Microscopic movement of Liquids.

June 22. The experiment for showing the internal motion of liquors was made, by putting some small pieces of charcoal into spirit of wine in an open glass, which being viewed through a large microscope appeared to have a very vehement motion every way, though to the naked eye there appeared none.

Mr. HOOKE said, that there was no such motion in common water or vinegar; and that he was of opinion, that all spirituous liquors would exhibit such a motion.

Sept. 1. Observed Sunspots.

Sept. 8. Observed Eclipse of Moon.

Sept. 16. Observed Saturn. See also under Nov. 14 and 20.

College of Physicians.

Oct. 19. HOOKE received £20 for acting as Surveyor during the building of the new College of Physicians in Warwick Lane, the foundations of which were being dug in March 1670–1. (*Cash book, R. Coll. Physicians.*)

Theory of Fossil Shells.

Nov. 2. A letter of Mr. LISTER to Mr. OLDENBURG dated at York 25 Aug. 1671, on Mr. STENO'S *Prodromus* concerning petrified shells, gave occasion to some of the members to discourse on the subject of petrified shells, some applauding Mr. LISTER'S notions of it; but Mr. HOOKE endeavouring to maintain his own opinion, that all those shells are the *exuviae* of animals.

New Metal.

A certain substance seeming to be a new kind of metal, was

delivered to Mr. HOOKE, to recommend it to Mr. SLINGESBY and the officers of the mint, in order that they might try, whether they could any way destroy it; with a request, that they would impart to the society the result of their trials.

Clock.

Nov. 9. Mr. HOOKE produced a watch, to show a way of making a clock to go twice as long as before, only by the contrivance of a little piece of wire added to an ordinary clock. The matter having been debated, Mr. HOOKE was desired to put it into effect; which he said he intended to do in a clock of his, that went eighteen months; which by this means would go three years with once winding up.

Nov. 14.

(20) *Some communications confirming the present appearance of the Ring about Saturn by M. Hugens de Zulichem and Mr. Hook.*

Phil. Trans., No. 65, p. 2093, November 14, 1670.

New way of dividing a Quadrant.

Nov. 16. Mr. HOOKE promised a new way of dividing a small quadrant to make astronomical observations with, as distinctly as with far greater ones. This he said was demonstrative, and he promised to bring in such a one at the next meeting, together with the demonstration, to be registered.

Eclipse of Moon.

There was read his account of the late solar eclipse of the moon 8 Sept. 1671; which was ordered to be registered.

Tides and Magnetic conditions in Iceland.

It was ordered, that more queries be sent to PAUL BIORNONIUS of Iceland, especially such as relate to the tides, and the magnetical declinations and inclinations in that country, and in several places thereof; in respect of which letter Mr. HOOKE was desired to draw up some directions, and to cause a long magnetical needle to be made in order to be sent thither.

Nov. 20.

(21) *Observations made by Mr. Hook both of the Solar Spots lately discovered [Sept. 1] and the Eclipse of the Moon of Sept. 8 1671.* [With a text figure.]

Phil. Trans., No. 77, pp. 2295–6, November 20, 1671.

Waywiser.

Nov. 23. Mr. Hooke produced an instrument contrived by himself to show the point of the compass, in which a person travels. He was desired to bring in the description of it in writing; as also to endeavour to compound this with that instrument, which he had produced before, whereby the way of a traveller may be traced upon a piece of paper, that so by one and the same instrument a traveller may make the map of the country, through which he passes, and at the same time know, to what quarter of the world he goes.

New Quadrant.

He produced a specimen of his new quadrant, which being but of seventeen inches would perform the same as a quadrant of twenty-four feet.

This quadrant was ordered to be fitted up in all its parts, that the use of it might the better appear.

Arch of Cupola.

Dec. 7. Mr. Hooke produced the representation of the figure of the arch of a cupola for the sustaining such and such determinate weights, and found it to be a cubico-parabolical conoid; adding, that by this figure might be determined all the difficulties in architecture about arches and butments.

He was desired to bring in the demonstration and description of it in writing to be registered.

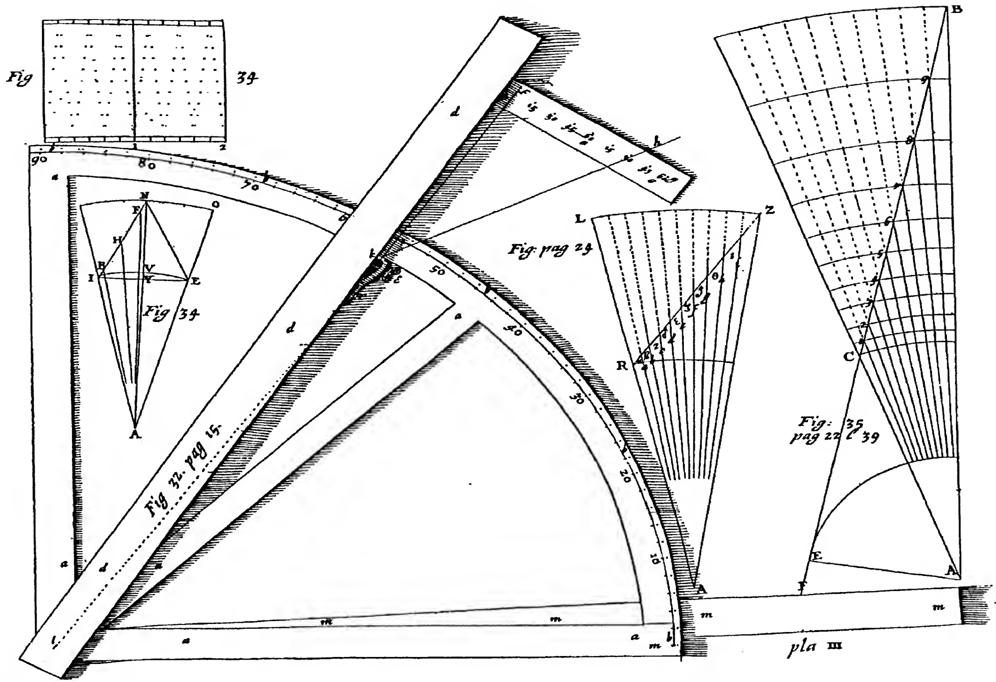
Mercury and Wood.

Dec. 14. Mr. Hooke mentioned, that he had prepared an experiment, to show what degree of force will make air and quicksilver pass through wood; but that something was broken in the carrying it, which obliged him to defer this experiment till the next meeting.

Cider Presses.

He produced three several new contrivances of cider-presses for both breaking and squeezing the apples and pears with ease and expedition. The one was with two pinions turning upon one another. The other he represented in a crooked line, having a kind of a mill-box and a roller at the bottom, and by its motion breaking, squeezing, and throwing out the fruit. The third was with four cylinders turning one another, the apples coming between on two sides, and going out on the two cross-sides. He was desired to bring in a description of these engines in writing, to be entered in the register-book.[1]

[1] A new-invented *Ingenio* or Cider-mill was figured and described by J. W. in his *Treatise of Cider*, printed in 1676. It was to be had 'made



HOOKE'S SMALL QUADRANT. *From his* Animadversions.

It was made with an attachment carrying an obliquely strained hair for the very accurate measurement of angles.

FIG. 34. Diagram to illustrate Tycho Brahe's method of measuring angles.

Tablature of Music.

Mr. Hooke discoursed of a way of making a very compendious tablature of music; which he was desired to give in writing.

Dec. 21. Mr. Hooke brought in a written account of what he had proposed at the last meeting about the facilitating of a musical tablature; which being read, he was desired to complete it, and to bring in an example both of the common and this new way of tablature at the next meeting.

Mercury and Wood.

The experiment formerly produced by Mr. Hooke, to show, what force would make air and mercury pass through wood was called for, but not succeeding, was ordered to be repeated at the next meeting.

1671/2

Jan. 11. Mr. Hooke was exhorted to pursue and finish his way of measuring a degree, which he promised to do, hoping to bring it to a greater exactness and nearness.

Optical Lenses.

Jan. 18. Mr. Hooke made a proposition of a highly considerable improvement of all sorts of optic burning-glasses; which was this:

The perfection of telescopes, microscopes, scotoscopes, and burning-glasses, from lentes of figures as easily and perfectly made as plain and spherical, by which the light and apparent magnitude of bodies may be most prodigiously and regularly increased; and whatever almost hath been in notion and imagination, or desired in optics, may be performed with great facility and truth.[1]

The way of performing this he lodged in these characters:

a c e f i l n o p r s t u x

4 4 8 3 4 2 2 4 2 6 4 3 4 2.

He received the thanks of the society, and was desired to impart the thing itself to the President for his lordship's perusal.

Telescopes and Microscopes.

Jan. 25. The President being desired to declare to the society, whether he had considered of Mr. Hooke's late proposition of bringing telescopes and microscopes, &c. to perfection, said, that he had not yet had time to examine it well; but, by what he had seen, he could not but have a good opinion of it.

exactly by John Delamere a Joyner in Petersfield in Hampshire, from 20*s*. to 30*s*. price apiece, according as they are either single or double'.

[1] For a slightly different version, see p. 396.

This was seconded by Dr. WREN, who had also been made acquainted with it by the inventor.

The society urged the President and Mr. HOOKE, that something might be undertaken in this matter, that might convince the world of the reality thereof.

Wood.

Mr. HOOKE was put in mind of the experiment of forcing mercury and air through wood.

Jan. 25. WALLIS wrote to COLLINS from Oxford. 'I am very glad of the improvements of the Microscope both by Mr. NEWTON and Mr. HOOKE. I have no acquaintance with the former, but to the latter you may present my services, and that I could wish he would not only in a cypher, but more at large commit it to writing, and either keep it in his own hands, or leave sealed up with Mr. OLDENBURG as a public person, till he be ready to publish something of it. However, that he would not suffer himself by the multitude of businesses to be diverted from perfecting his design, which doth but too often prejudice things of this nature.

I would fain that Mr. H. and Mr. N. would set themselves in earnest for promoting the designs about telescopes, that others may not steal from us what our nation invents, only for our neglect to publish them ourselves.

[Rigaud, *Correspondence*, p. 529.]

Jan. 31. FLAMSTEED wrote to COLLINS asking that HOOKE might be informed that the planet Jupiter would pass under the star, 24th of Leo, 11 minutes.

Newton's Telescope.

Feb. 1. The four-foot telescope of Mr. NEWTON's invention was produced again, being improved since the last meeting. It was recommended to Mr. HOOKE, to see it perfected as far as it was capable of being.

Telescopes.

Mr. HOOKE was put in mind to give, as soon as he could, a specimen of his great proposition of making telescopes, microscopes, &c. in perfection.

Newton's theory of Colour.

Feb. 8. Mr. ISAAC NEWTON wrote from Cambridge, February 6, 1671/2, concerning his discovery of the nature of light, refractions, and colours; importing, that light is not a similar, but a heterogeneous body, consisting of different rays, which had essentially different refractions, abstracted from bodies through

which they pass; and that colours are produced from such and such rays, whereof some, in their own nature, are disposed to produce red, others green, others blue, others purple, &c. and that whiteness is nothing but a mixture of all sorts of colours, or that it is produced by all sorts of colours blended together.

It was ordered, that this discourse be entered into the register-book; and that the Bishop of Salisbury, Mr. BOYLE, and Mr. HOOKE be desired to peruse and consider it, and bring in a report of it to the society.

Feb. 15. Mr. HOOKE's considerations upon Mr. NEWTON's discourse on light and colours were read. Mr. HOOKE was thanked for the pains taken in bringing in such ingenious reflections; and it was ordered, that this paper should be registered, and a copy of it immediately sent to Mr. NEWTON: and that in the meantime the printing of Mr. NEWTON's discourse by itself might go on, if he did not contradict it; and that Mr. HOOKE's paper might be printed afterwards, it not being thought fit to print them together, lest Mr. NEWTON should look upon it as a disrespect, in printing so sudden a refutation of a discourse of his, which had met with so much applause at the society but a few days before.

Newton's theory of Colour.

Mr. HOOKE's paper was as follows:

I have perused the discourse of Mr. NEWTON about colours and refractions, and I was not a little pleased with the niceness and curiosity of his observations. But, though I wholly agree with him as to the truth of those he hath alleged, as having, by many hundreds of trials, found them so; yet as to his hypothesis of solving the phenomena of colours thereby, I confess, I cannot see yet any undeniable argument to convince me of the certainty thereof. For all the experiments and observations I have hitherto made, nay, and even those very experiments, which he allegeth, do seem to me to prove, that *white* is nothing but a pulse or motion, propagated through an homogeneous, uniform, and transparent medium: and that colour is nothing but the disturbance of that light, by the communication of that pulse to other transparent mediums, that is, by the refraction thereof: that *whiteness* and *blackness* are nothing but the plenty or scarcity of the undisturbed rays of light: and that the two colours (than the which there are not more uncompounded in nature) are nothing but the effects of a compounded pulse, or disturbed propagation of motion caused by refraction.

But, how certain soever I think myself of my hypothesis (which I did not take up without first trying some hundreds of

experiments) yet I should be very glad to meet with one *experimentum crucis* from Mr. NEWTON, that should divorce me from it. But it is not that, which he so calls, will do the turn; for the same phenomenon will be solved by my hypothesis, as well as by his, without any manner of difficulty or straining: nay, I will undertake to show another hypothesis, differing from both his and mine, that shall do the same thing.

That the ray of light is as it were split or rarefied by refraction, is most certain; and that thereby a differing pulse is propagated, both on those sides, and in all the middle parts of the ray, is easy to be conceived: and also, that differing pulses or compound motions should make differing impressions on the eye, brain, or sense, is also easy to be conceived: and that, whatever refracting medium does again reduce it to its primitive simple motion by destroying the adventitious, does likewise restore it to its primitive whiteness and simplicity.

But why there is a necessity, that all those motions, or whatever else it be that makes colours, should be originally in the simple rays of light, I do not yet understand the necessity of, no more than that all those sounds must be in the air of the bellows, which are afterwards heard to issue from the organ-pipes; or in the string, which are afterwards, by different stoppings and strikings produced; which string (by the way) is a pretty representation of the shape of a refracted ray to the eye; and the manner of it may be somewhat imagined by the similitude thereof: for the ray is like the string, strained between the luminous object and the eye, and the stop or fingers is like the refracting surface, on the one side of which the string hath no motion, on the other a vibrating one. Now we may say indeed and imagine, that the rest or straightness of the string is caused by the cessation of motions, or coalition of all vibrations; and that all the vibrations are dormant in it: but yet it seems more natural to me to imagine it the other way.

And I am a little troubled, that this supposition should make Mr. NEWTON wholly lay aside the thoughts of improving telescopes and microscopes by refractions; since it is not improbable, but that he, that hath made so very good an improvement of telescopes by his own trials upon reflection, would, if he had prosecuted it, have done more by refraction. And that reflection is not the only way of improving telescopes, I may possibly hereafter show some proof of. The truth is, the difficulty of removing that inconvenience of the splitting of the ray, and consequently of the effect of colours, is very great; but yet not insuperable. I have made many trials, both for telescopes and microscopes by reflection, which I have mentioned in my *Micrographia*, but deserted it as to telescopes, when I considered,

that the focus of the spherical concave is not a point but a line, and that the rays are less true reflected to a point by a concave, than refracted by a convex; which made me seek that by refraction, which I found could not rationally be expected by reflection: nor indeed could I find any effect of it by one of six feet radius, which, about seven or eight years since, Mr. REEVE made for Mr. GREGORY, with which I made several trials; but it now appears it was for want of a good encheiria (from which cause many good experiments have been lost) both which considerations discouraged me from attempting further that way; especially since I found the parabola much more difficult to describe, than the hyperbola or ellipse. And I was wholly taken from the thoughts of it, by lighting on divers ways, which in theory answered all I could wish for; though having much more business, I could not attend to bring them into use for telescopes; though for microscopes I have for a good while used it. Thus much as to the preamble; I shall now consider the propositions themselves.

First then, Mr. NEWTON allegeth, that as the rays of light differ in refrangibility, so they differ in their disposition to exhibit this or that colour: with which I do in the main agree; that is, that the ray by refraction is, as it were, split or rarefied, and that the one side, namely that which is most refracted, gives a *blue*, and that which is least a *red*: the intermediate are the dilutings and intermixtures of those two, which I thus explain. The motion of light in an uniform medium, in which it is generated, is propagated by simple and uniform pulses or waves, which are at right angles with the line of direction; but falling obliquely on the refracting medium, it receives another impression or motion, which disturbs the former motion, somewhat like the vibration of a string: and that, which was before a line, now becomes a triangular superficies, in which the pulse is not propagated at right angles with its line of direction, but askew, as I have more at large explained in my *Micrographia*; and that, which makes excursions on the one side, impresses a compound motion on the bottom of the eye, of which we have the imagination of *red*; and that, which makes excursions on the other, causes a sensation, which we imagine a *blue*; and so of all the intermediate dilutings of those colours. Now, that the intermediate are nothing but the dilutings of those two primary, I hope I have sufficiently proved by the experiment of the two wedge-like boxes, described in my *Micrographia*. Upon this account I cannot assent to the latter part of the proposition, that colours are not qualifications of light, derived from refractions, or reflections of natural bodies, but original and connate properties, &c.

The second proposition I wholly allow, not exactly in the

sense there meant, but with my manner of expressing it; that is, that part of the split ray, which is most bent, exhibits a blue, that which is least, a red, and the middle parts middling colours; and that those parts will always exhibit those colours till the compound motions are destroyed, and reduced by other motions to one simple and uniform pulse as it was at first.

And this will easily explain and give a reason of the phenomena of the third proposition, to which I do readily assent in all cases, except where the split ray is made by another refraction, to become entire and uniform, again to diverge and separate, which explains his fourth proposition.

But as to the fifth, that there are an indefinite variety of primary or original colours, amongst which are yellow, green, violet, purple, orange, &c. and an infinite number of intermediate gradations, I cannot assent thereunto, as supposing it wholly useless to multiply entities without necessity, since I have elsewhere shown, that all the varieties of colours in the world may be made of two. I agree in the sixth, but cannot approve of his way of explicating the seventh. How the split ray being made doth produce a clear and uniform light, I have before showed; that is, by being united thereby from a superficial motion, which is susceptible of two, to a lineary, which is susceptible of only one motion; and it is as easy to conceive how all those motions again appear after the rays are again split or rarefied. He, that shall but a little consider the undulations on the surface of a small river of water, in a gutter, or the like, will easily see the whole manner curiously exemplified.

The eighth proposition I cannot at all assent to, for the reasons above; and the reasons of the blue flame of brimstone, of the yellow of a candle, the green of copper, and the various colours of the stars, and other luminous bodies, I take to proceed from quite another cause, easily explained by my former hypothesis.

I agree with the observations of the ninth, tenth, and eleventh, though not with his theory, as finding it not absolutely necessary, being as easily and naturally explained and solved by my hypothesis.

The reason of the phenomena of my experiment, which he allegeth, is as easily solvable by my hypothesis as by his; as are also those, which are mentioned in the thirteenth. I do not therefore see any absolute necessity to believe his theory demonstrated, since I can assure Mr. Newton, I cannot only solve all the phenomena of light and colours by the hypothesis I have formerly printed, and now explicate them by, but by two or three other very differing from it, and from this, which he hath described in his ingenious discourse.

Nor would I be understood to have said all this against his

theory, as it is an hypothesis; for I do most readily agree with them in every part thereof, and esteem it very subtle and ingenious, and capable of solving all the phenomena of colours: but I cannot think it to be the only hypothesis, nor so certain as mathematical demonstrations.

But grant his first proposition, that light is a body, and that as many colours as degrees thereof as there may be, so many sorts of bodies there may be, all which compounded together would make white; and grant further, that all luminous bodies are compounded of such substances condensed, and that whilst they shine, they do continually send out an indefinite quantity thereof, every way *in orbem*, which in a moment of time doth disperse itself to the utmost and most indefinite bounds of the universe; granting these, I say, I do suppose there will be no great difficulty to demonstrate all the rest of his curious theory: though yet, methinks, all the coloured bodies in the world compounded together should not make a white body, and I should be glad to see an experiment of that kind done on the other side. If my supposition be granted, that light is nothing but a simple and uniform motion, or pulse of a homogeneous and adopted (that is a transparent) medium, propagated from the luminous body *in orbem*, to all imaginable distances in a moment of time, and that that motion is first begun by some other kind of motion in the luminous body; such as by the dissolution of sulphureous bodies by the air, or by the working of the air, or the several component parts one upon another, in rotten wood, or putrefying fish, or by an external stroke, as in diamond, sugar, the sea-water, or two flints or crystal rubbed together; and that this motion is propagated through all bodies susceptible thereof, but is blended or mixed with other adventitious motions, generated by the obliquity of the stroke upon a refracting body; and that, so long as those motions remain distinct in the same part of the medium or propagated ray, so long they produce the same effect, but when blended by other motions, they produce other effects: and supposing, that by a direct contrary motion to the newly impressed, that adventitious one be destroyed and reduced to the first simple motion; I believe Mr. NEWTON will think it no difficult matter, by my hypothesis, to solve all the phenomena, not only of the prism, tinged liquors, and solid bodies, but of the colours of plated bodies, which seem to have the greatest difficulty. It is true, I can, in my supposition, conceive the white or uniform motion of light to be compounded of the compound motions of all the other colours, as any one straight and uniform motion may be compounded of thousands of compound motions, in the same manner as DESCARTES explicates the reason of the refraction; but I see

no necessity of it. If Mr. NEWTON hath any argument, that he supposes an absolute demonstration of his theory, I should be very glad to be convinced by it, the phenomena of light and colours being, in my opinion, as well worthy of contemplation, as anything else in the world.

Newton's six-foot Telescope.

Mr. HOOKE was put in mind of the six-foot tube of Mr. NEWTON'S invention, and of bringing in a specimen of the effect of his own proposition.

Feb. 20. LETTER FROM NEWTON TO OLDENBURG.

Cambridge.

Sir, I received your's of Feb. 19th. And having considered Mr. HOOKE'S observations on my discourse, am glad that so acute an objector hath said nothing that can enervate any part of it. For I am still of the same judgement, and doubt not but that upon severer examinations, it will be found as certain a truth as I have asserted it. You shall very suddenly have an answer. [Rigaud, *Correspondence,* p. 318.]

Combustion of Candle.

Feb. 22. Mr. HOOKE made an experiment, to show, that, besides the flame and smoke of a candle, there is a continual stream rising up from it, distinct from the air; concerning which, he said, that he conceived, that as the action of the air upon the parts of the candle heated, or the dissolution of them, was the flame; so the composition of the air, and the relic of the effluvia of the parts of the candle dissolved thereby, made this stream, which continually ascended, and kept itself distinct from the air.

Theory of Light and Colour.

Mr. NEWTON'S letter to Mr. OLDENBURG, dated at Cambridge, February 20, 1671/2, was read, promising an answer to Mr. HOOKE'S observations upon his new theory of light and colour. [See above.]

Mr. HOOKE was desired to produce at the next meeting the experiment of representing a blue and red colour in two wedge-like boxes.

Combustion of Candle.

Feb. 29. The experiment exhibited at the last meeting, to show the steam about the flame of a candle distinct from the smoke and air, was repeated, and proved satisfactory. Mr. HOOKE

was ordered to give an account in writing of the manner of representing this experiment.

Signalling by Semaphore.

He proposed a way for a very speedy conveyance of intelligence from place to place by the sight assisted with telescopes, to be employed on high places, by the correspondents using a secret character, proportioned in bigness according to the distance at which they are to be seen, &c.

The paper of this proposition, and the particulars of the manner of practising it, were read, but not left by Mr. HOOKE to be registered, but taken away by him.

It was ordered, that some experiment should be made of this proposition at the next meeting; which Mr. HOOKE promised to do.

Signalling.

Mar. 7. An experiment was made of the method proposed by Mr. HOOKE at the last meeting, of conveying intelligence from place to place, which was performed from Arundel House garden to a boat lying near the shore on the other side of the Thames, by letters of a foot long, and glasses of two feet long, the distance being about half a mile.

The contrivance was applauded as very ingenious, and the author desired to make more trials of it at greater distances.

The President objected, that the use of it would be often hindered by hazy weather.

Others intimated, that the greatest difficulty in the practice would be in proportioning the glass and the letters, viz. at what distance a glass of such or such a length shall discover characters of such and such a bigness.

Soap-bubble.

Mr. HOOKE promised to show at the next meeting something having neither reflection nor refraction, and yet diaphanous.

Combustion of Candle.

Mar. 14. Mr. HOOKE brought in an account of an experiment shown before the society, February 29, and designed to prove, that the substance of a candle, or lamp, is dissolved by the air, and the greatest part thereof reduced to a fluid of the form of air. This paper was ordered to be registered, and was as follows:

I took a large concave reflecting glass, or a large convex refracting glass, and so placed it in respect to my eye, that a candle set at a certain distance beyond the refracting glass, or

between the eye and the superficies of the reflecting glass, enlightened the whole area of the said glasses in respect to the eye. Then continuing to keep the eye in that place, where the area of the said glasses appeared to be wholly filled with the flame of the candle, I caused another candle to be placed very near the said glasses, between the eye and the glass; or beyond also, if I made use of the refracting glass. Then looking steadfastly at the flame of this last candle, it was very plain to be perceived, that the flame thereof was encompassed with a stream of liquor, which seemed to issue out of the wick, and to ascend up in a continual current, or *jet d'eau*, to keep itself entire, and unmixed with the ambient air, notwithstanding that it was a considerable way carried above the aforesaid flame. It was further very plain, that the said distinct fluid did make several turnings, whirlings, or vortices in the ambient air, as it ascended higher and higher, and by degrees mixed itself with the ambient air. It was yet further observable, that the shining flame was placed in the middle of this *jet d'eau*, at the lower end thereof; but that it did not ascend proportionally in height to the height of the *jet d'eau*; that, where the tip of the flame ended, there ascended up a small line, of an opacous body, or smoke, which, to a good height above the flame, kept the middle of the stream. The manifestation of this phenomenon was from the differing refractions of the body of the *jet d'eau* from that of the ambient air: for the flame of the first candle being but small, and placed at a considerable distance from the refracting, or reflecting glass, the smallest variation in the refraction of the medium between the first glass and the eye caused the darkness to intermix with the light; so to exhibit the appearance of the heterogeneous *jet d'eau*. This *jet d'eau* I suppose to be nothing else but the mixture of the air with the parts of the candle, which are dissolved into it in the flame; for the air being (as I have elsewhere proved) the universal menstruum, or dissolvent, of all sulphurous bodies, and the action of dissolution in most bodies producing heat and light; it is manifest by the flame, that there is such a solution, and it is not probable that the body so intermixed, should immediately so perfectly intermix itself with the rest of the air, as not to appear, for a time, distinct from it, though it doth afterwards intermix itself with the rest of the air. The reasons why this mixed body (which certainly is otherwise heavier than the air, and so ought to descend) doth, notwithstanding, ascend with great swiftness, is first, from the ascent of the flame in the middle; and next, from the extraordinary rarefaction of the same, by the same nearness and centrality of the flame and heat; whereby it is made much lighter than the ambient air. A phenomenon not much unlike this may be produced by several

bodies dissolved in oil of vitriol, wherein all the appearances, but light, are very perfectly represented.

Mr. HOOKE promised to exhibit at the next meeting, an experiment to show a phenomenon not unlike this, to be produced by several bodies dissolved in oil of vitriol.

Soap-bubbles.

He showed a phenomenon in a bubble raised by water and soap, wherein there appeared something on water which had neither reflection nor refraction, and yet was diaphanous. He was desired to bring an account of this in writing, with his thoughts upon it.

Comet.

Mar. 21. The letter of Mr. HEVELIUS to Mr. OLDENBURG, dated at Danzig, March 9, 1671/2, giving notice of a comet observed by him in Andromeda, having been communicated to Mr. HOOKE some days before this meeting, he said, that he had not hitherto discovered any comet.

? *March, n. d.* NEWTON, according to a copy by COLLINS probably for FLAMSTEED, wrote a letter describing his 6-inch telescope which showed Jupiter Satellites and Venus horned, with a power of 40 diameters. Whereupon Mr. COCK was ordered to make a 4-foot telescope of the same kind.[1] Mr. HOOKE 'seeing this telescope to obtain esteem, about a month since put in a proposal in writing to the R. S. in words to this effect:

'The perfection of telescopes, microscopes, scotoscopes, and burning glasses, by figures as easily made as those that are plane or spherical, whereby the light and magnitude of objects is prodigiously increased, and whatsoever hath hitherto been attempted or almost desired in dioptrics accomplished—with a cipher containing the mystery; the which he disclosed to the Lord BROUNCKER and Dr. WREN, who report plausibly of it, and what is done in this way is performed by glass refraction.[2]

'Mr. H. moreover affirmed *coram multis* that in the year 1664, he made a little tube of about an inch long to put in his fob, which performs more than any telescope of 50 feet long, made after the common manner; but the plague happening . . . and the fire . . . he neglected to prosecute the same, being unwilling the glass grinders should know anything of the secret.'

[Undated MS., Collins in Rigaud, *Correspondence*, p. 291.]

[1] March 14, 1671–2. [2] See under Jan. 18, 1671/2.